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BOUNDARY LAYER INTEGRAL MATRIX PROCEDURE

FOR JANNAF ROCKET ENGINE PERFORMANCE
EVALUATION METHODOLOGY

BLIMP-J User's Manual

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FOREWORD

This User's Manual was prepared by Dr. R. Michael Evans of the Aerotherm Division of Acurex Corporation for the JANNAF Performance Standardization Working Group under Contract NAS8-30930 from the George C. Marshall Space Flight Center. This manual contains complete documentation for the BLIMP-J version of the BLIMP computer program. This program serves as the standard boundary layer prediction method for the JANNAF rocket engine performance prediction and evaluation procedure.

The BLIMP program was originally developed for NASA/MSC under Contract NAS9-4599 by Mr. Eugene P. Bartlett and Dr. Robert M. Kendall. It was extended to turbulent flow under joint sponsorship of NASA/MSC and the Air Force Weapons Laboratory. The present version contains several extensions to the previous versions.

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ABSTRACT

The JANNAF standard procedure for prediction of boundary layer effects in liquid rocket engine thrust chambers is described. The computer program, designated as Version J of the Boundary Layer Integral Matrix Procedure (BLIMP-J), computes the nonsimilar chemically reacting laminar or turbulent boundary layer for ablating, transpiration cooled or nonablating internal flow configurations. The flow can be considered to be planar or axisymmetric. The program considers either local thermodynamic equilibrium or frozen composition for a general propellant gas (no restriction on elemental composition). Mass addition, either by surface ablation or injection, for as many as three different materials is permitted. A wide variety of surface boundary conditions are available ranging from assigned wall temperatures and mass injection rates to surface equilibrium while satisfying a steady-state wall energy balance. The program uses a novel numerical solution procedure, termed an integral matrix approach, which is equivalent to a higher order finite difference approach (using spline fits). Thus, the code is capable, within practical limits, of obtaining very accurate and economical solutions to the governing differential equations (momentum, energy, and species). The interface of this program with other programs of the JANNAF standardized performance prediction and evaluation procedure for rocket engines is also described.

Copies of this document and the computer program can be obtained from the Chemical Propulsion Information Agency (CPIA), APL/JHU, 8621 Georgia Avenue, Silver Spring, Maryland, 20910, Attn: Mr. T. L. Reedy.

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LIST OF SYMBOLS

c	constant introduced in the α_H constraint (Equation (3-3))
c_t	constant introduced in the approximation for multicomponent thermal diffusion coefficients embodied in Equation (2-20). Tentatively established by correlation of data to be -0.5.
C	product of density and viscosity normalized by their reference values (defined by Equation (3-11))
C_s	specific heat of solid
\bar{C}_p	frozen specific heat of the gas mixture
\tilde{C}_p	property of the gas mixture which reduces to \bar{C}_p when diffusion coefficients are assumed equal for all species (defined by Equation (2-21))
C_{pi}	specific heat of species i
d_0, d_1, d_2	coefficients defined in finite-difference representation of streamwise derivation (defined in Equations (3-34) and (3-35) for two- and three-point difference relations, respectively)
\bar{D}	a reference binary diffusion coefficient introduced by the approximation for binary diffusion coefficients embodied in Equation (2-19) (defined in Equation (2-42))
D_i^T	multicomponent thermal diffusion coefficient for species i
D_{ij}	multicomponent diffusion coefficient for species i and j
D	diffusion coefficient for all species when all D_{ij} are equal
D_{ij}	binary diffusion coefficient for species i and j
ERROR	errors for the various equations during Newton-Raphson iteration (driven toward zero in the iteration)
f, f', f'', f'''	stream function (defined by Equation (3-4)) and derivative with respect to η .
F_i	diffusion factor for species i introduced by the approximation for binary diffusion coefficient embodied in Equation (2-19)

LIST OF SYMBOLS (Continued)

G_j^0	Gibbs free energy for the j^{th} species
h	static enthalpy of the gas (defined by Equation (2-14))
h_w	static enthalpy of the gas at the wall
\tilde{h}	property of the gas mixture which reduces to the static enthalpy h when diffusion coefficients are assumed equal for all species (defined by Equation (2-21))
h_c	enthalpy of surface material (e.g., char) removed by combustion, sublimation, or vaporization
h_g	enthalpy of gas which enters boundary layer without phase change at <u>the surface</u> (e.g., pyrolysis gases)
h_i	enthalpy of species i
h_i^0	heat of formation
h_{ℓ}	enthalpy of ℓ^{th} component surface material (e.g., graphite) removed in the condensed phase (e.g., by melting with subsequent liquid run-off or by spallation)
H_{Ti}	inviscid flow total enthalpy (relative to zero th streamline reference total enthalpy)
H_T	total enthalpy (defined by Equation (2-14))
j_i	diffusional mass flux of species i per unit area away from the surface
j_k	diffusional mass flux of element k per unit area away from the surface
k, k_m	mixing length constants
K	total number of elements
K_i	mass fraction of molecular species i
\tilde{K}_k	total mass fraction of element (or base gas) k irrespective of molecular configuration (defined by Equation (2-10))

LIST OF SYMBOLS (Continued)

K_{pm}	partial pressure equilibrium constant for m^{th} chemical reaction
ℓ	mixing length
$\tilde{\ell}$	dimensionless mixing length (defined by Equation (3-15))
L	$= 2\pi\sigma$ for axisymmetric flow, $= 1$ for 2-D flow
\dot{m}	mass flow rate per unit area
\dot{m}_c	mass removal rate per unit area of surface material (e.g., char) by combustion, sublimation, or vaporization
\dot{m}_g	mass flow rate per unit area of gas which enters boundary layer without phase change at the surface (e.g., pyrolysis gases)
$\dot{m}_{r\ell}$	mass removal rate per unit area of ℓ^{th} component surface material (e.g., silica) in the condensed phase (e.g., by melting with subsequent liquid runoff or by spallation)
M	molecular weight of the gas mixture
M_i	molecular weight of species i
N	number of nodal points across the boundary layer selected for the purpose of the numerical solution procedure
p	dummy variable representing f' , H_T , or \tilde{K}_k
P	pressure
P_i	partial pressure of species i
Pr	frozen Prandtl number of the gas mixture (defined by Equation (2-54))
Pr_t	turbulent Prandtl number (defined in Section 2.5.1)
q_a	diffusional heat flux per unit area away from the surface
q_{cond}	heat conduction per unit area into the surface material

LIST OF SYMBOLS (Continued)

q_r	one-dimensional radiant heat flux (toward the surface), that is, the <u>net</u> rate per unit area at which radiant energy is transferred across a plane in the boundary layer parallel to the surface
r	metric coefficient for streamline spreading (equal to local radius in the boundary layer in a meridian plane for axisymmetric flow)
r_0	surface value of r
R	universal gas constant
Re	Reynolds number; subscripted with the length scale if other than s
s	distance along body from stagnation point or leading edge
s_i	entropy of species i
\overline{Sc}	reference system Schmidt number (defined by Equation (2-55))
Sc_t	turbulent Schmidt number (defined in Section 2.5.1)
SP_i	mass fraction of i^{th} species
t	parameter defined to simplify problems with transverse curvature (defined by Equation (3-10))
T	static temperature
u	velocity component parallel to body surface
u_τ	shear velocity (defined in Equation (2-69))
v	velocity component normal to body surface
x_i	mole fraction of species i
XP_1, XP_2, \dots	truncated series obtained in Taylor series expansion of $\int_{i-1}^i f' p \, dn$ (defined by Equation (3-39))
y	distance from surface into the boundary layer, measured normal to the surface

LIST OF SYMBOLS (Continued)

y^+	dimensionless y-coordinate (defined in Section 2.5.3)
y_a^+	constant in the mixing length differential equation (see Equation (2-64))
Z_i	a quantity for species i which is introduced as a result of the approximation for binary diffusion coefficients and reduces to K_i when all diffusion coefficients are assumed equal (defined by Equation (2-21))
\tilde{Z}_k	a quantity for element (or base species) k which is introduced as a result of the approximation for binary diffusion coefficients and reduces to K_k when all diffusion coefficients are assumed equal (defined by Equation (2-21))
ZP_1, ZP_2, \dots	truncated series obtained in Taylor series expansion of integrals involving nonsimilar terms (defined by Equation (3-45))
α^*	flux normalizing parameter (defined by Equation (3-19))
α_H	normalizing parameter used in definition of $\bar{\eta}$ (see Equation (3-2), defined implicitly by use of a constraint such as Equation (3-3))
α_{ki}	mass fraction of element (or base species) k in species i
β_p	streamwise pressure-gradient parameter (defined by Equation (3-13))
β_v	streamwise velocity-gradient parameter (defined by Equation (3-12))
δ	y-dimension normalizing parameter (defined by Equation (3-15))
$\Delta_{\ell-1}$	logarithmic distance between two streamwise positions denoted by the subscripts ℓ and $\ell-1$ (defined by Equation (3-36))
$\Delta f_i, \Delta f'_i, \dots$	corrections for f_i, f'_i, \dots , during Newton-Raphson iteration
ΔG_j^0	change in standard state free energy for j th chemical reaction
δ^*	velocity defect thickness (defined by Equation (2-60))
$\delta\eta$	distance between two boundary layer nodal points

LIST OF SYMBOLS (Continued)

\hat{n}, \bar{n}, n	transformed coordinate in a direction normal to the surface (defined by Equations (3-1), (3-2) and (3-6))
θ, ϕ	angle between a surface normal and a normal to the body centerline or angle between a surface tangent and the body centerline
λ	thermal conductivity
μ	shear viscosity
$\mu_1, \mu_2, \mu_3, \mu_4$	properties of the gas mixture (defined by Equation (2-21)) which reduce to unity, to M , to $1/M$, and to $\ln M$, respectively, for assumed equal diffusion coefficients
ν	kinematic viscosity
$\xi, \bar{\xi}, \xi$	transformed streamwise coordinate (defined by Equations (3-1), (3-2) and (3-6))
ρ	density
ρ_w^v	total mass flux per unit area into the boundary layer
$\rho \epsilon_{D_i}$	individual species turbulent eddy diffusivity
$\rho \epsilon_D$	average turbulent eddy diffusivity, where it is assumed that all $\rho \epsilon_{D_i} = \rho \epsilon_D$
$\rho \epsilon_H$	turbulent eddy conductivity
$\rho \epsilon_M$	turbulent eddy viscosity
$\rho \tilde{\epsilon}_M$	dimensionless eddy viscosity (defined by Equation (3-15))
σ	Stefan-Boltzmann constant
ϕ_k	elemental source term (see discussion following Equation (2-10), set to zero)
τ	local shear stress
ψ_i	rate of mass generation of species i per unit volume due to chemical reaction

LIST OF SYMBOLS (Continued)

Subscripts

edge,e	pertains to boundary-layer edge
equil	pertains to surface equilibrium requirement
i	pertains to the i^{th} species or to the i^{th} nodal point in the boundary layer, starting with $i = 1$ at the surface
j	pertains to j^{th} species
k	pertains to k^{th} element (or base species)
ℓ	pertains to ℓ^{th} streamwise position
m	pertains to m^{th} iteration during the Newton-Raphson iteration process
n	pertains to the n^{th} nodal point, corresponding to the outer edge of the boundary layer solution
s	pertains to solid
sp	pertains to the stagnation point
S.S.	pertains to the steady state energy balance requirement
w	pertains to wall or node 1
l	reference condition, usually taken as zero streamline from inviscid solution (synonymous with boundary-layer edge) in BLIMP-J but retained to distinguish between use of actual edge properties and reference properties)

Superscripts

κ	equal to unity for axisymmetric bodies and zero for one-dimensional bodies
*	signifies that quantity is normalized by α^* (e.g., $j_k^* = j_k/\alpha^*$)

LIST OF SYMBOLS (Concluded)

- ' represents partial differentiation with respect to η or $\hat{\eta}$ (usually η unless otherwise noted); also used to denote time differentiation in turbulent formulation
- molar specific thermodynamic property
- o initial state value, ex., h_C^0 is the enthalpy of the char materials in the virgin state

SECTION 1

INTRODUCTION

The BLIMP computer program was developed to provide a fast, highly accurate solution procedure for the general class of gas phase boundary layer flow problems encompassing a broad range of boundary conditions. The solution procedure applies to the laminar or turbulent, nonsimilar, multicomponent, equilibrium boundary layer for axisymmetric or planar flow and for general chemical systems. Version J of this program has been specially modified to interface with other JANNAF codes for performance prediction of liquid rocket motors.*

The initial development of the Boundary Layer Integral Matrix Procedure (BLIMP) was performed under NASA Contract NAS9-4599 and is presented in Reference 1. The turbulent model, which was later added, is described in Reference 2. In 1972 BLIMP was selected by the JANNAF Boundary Layer Subcommittee to fill the need for an efficient and accurate boundary layer prediction procedure. Shortly thereafter work began on revising the BLIMP code to satisfy special requirements for the JANNAF program. BLIMP is intended to serve as a rigorous boundary layer program in connection with other JANNAF reference programs such as CICM, DER, and TDK (References 3-5) for the prediction of liquid rocket motor performance. Special input and output procedures, have been included to facilitate this interface (see Section 6.10).

This manual is intended to contain complete documentation of the BLIMP-J program. Section 2 contains a description of the mathematical modeling of the boundary layer flow including discussions of the general conservation equations, turbulent flow, general chemistry considerations and evaluation of the thermodynamic properties. Three turbulent models are described and have been included in the program; although, the Kendall model is the accepted model in the JANNAF standardized prediction procedure. The last part of Section 2 includes a list of limitations of the current formulation. The governing equations are transformed to a new coordinate system and the integral matrix procedure is discussed in Section 3. The matrix form of the equations and the Newton-Raphson procedure are also discussed in Section 3. Section 4 contains a description of the subroutines, an overlay structure, a flow chart, a complete list of the program, and a list of the Fortran variables. Input instructions

*The JANNAF rocket engine performance prediction and evaluation procedure is completely described in Chemical Propulsion Information Agency publications 245 and 246.

including a description of the input quantities and suggested values for many of the input parameters are given in Section 5. The input instructions are expanded with detailed discussions of many program options and other user oriented information in Section 6. The BLIMP output, including some debug output, is described in Section 7. Three sample cases are presented in Section 8. Complete lists of the input and samples of the output are given.

SECTION 2

MATHEMATICAL MODEL OF THE BOUNDARY LAYER

The mathematical model for the chemically reacting boundary layer is presented in this section. The differential conservation equations which govern laminar or turbulent compressible flow for either planar or axisymmetric bodies are developed. In addition, the auxiliary relations for the equation of state for a chemically equilibrated mixture, multicomponent transport properties, and turbulent transport properties necessary for closure of the set of equations are given.

2.1 GENERAL CONSERVATION EQUATIONS

In the present analysis, the usual turbulent flow technique of breaking the species, velocity, and enthalpy fields into mean and fluctuating components, time averaging, and making appropriate order of magnitude approximations is used. The results of these manipulations will be taken as a point of departure for all the conservation equations. The species mass balance equation can thus be written as

$$\frac{\partial}{\partial s} (\rho u K_i r^\kappa) + \frac{\partial}{\partial y} (\rho v K_i r^\kappa) = \left[\left(\rho \epsilon_{D_i} \frac{\partial K_i}{\partial y} - j_i \right) r^\kappa \right] + \psi_i r^\kappa \quad (2-1)$$

where s and y are the streamwise and normal coordinates, respectively, u and v are the velocity components in the s and y directions, respectively, K_i is the mass fraction of species i , r is the metric coefficient for streamline spreading for three-dimensional flows (radius from the body centerline to the point of interest in a meridian plane for axisymmetric flow), κ is zero for a flat plate and unity for a body of revolution, ρ is the density, and ψ_i represents the rate of mass generation of species i per unit volume due to chemical reaction. The individual species turbulent eddy diffusivity $\rho \epsilon_{D_i}$ is defined in terms of the correlation of the fluctuating components of concentration and normal velocity, that is,

$$\rho \epsilon_{D_i} = - \frac{(\rho v)' K_i'}{\partial K_i / \partial y} \quad (2-2)$$

and j_i is the mass-diffusion rate of species i due to molecular processes. Since transverse curvature is to be included in the present analysis, r must be treated as a function of y whereas in the typical boundary layer analysis, r is set equal to r_0 , the surface value of r . The relationship between r , r_0 , and y is

$$r(s,y) = r_0(s) - y \cos \theta \quad (2-3)$$

The coordinate system being used, is shown in Figure 2-1.

In Equation (2-1) and in other conservation equations to follow, turbulent transport terms are expressed in Boussinesq form, that is, eddy viscosity, eddy diffusivity, and eddy conductivity. Hence all terms are time-averaged quantities and no need exists for using a superscript bar. In the order-of-magnitude arguments, terms of the following types have been eliminated: (1) triple correlations, (2) derivatives of turbulent correlations parallel to the wall, and (3) correlations involving turbulent components of molecular transport mechanisms.

When Equation (2-1) is summed over all species, the global continuity equation results:

$$\frac{\partial \rho u r^K}{\partial s} + \frac{\partial \rho v r^K}{\partial y} = 0 \quad (2-4)$$

Combining Equations (2-1) and (2-4), one obtains the species conservation equation

$$\rho u \frac{\partial K_i}{\partial s} + \rho v \frac{\partial K_i}{\partial y} = \frac{1}{r^K} \frac{\partial}{\partial y} \left[r^K \left(\rho \epsilon_{D_i} \frac{\partial K_i}{\partial y} - j_i \right) \right] + \psi_i \quad (2-5)$$

which can be written for each species i under consideration. The molecular diffusion rate j_i is expressed in general as

$$j_i = \frac{\rho}{M^2} \sum_{j \neq i} M_i M_j D_{ij} \frac{\partial x_j}{\partial y} - D_i^T \frac{\partial}{\partial y} \ln T \quad (2-6)$$

where D_{ij} is the multicomponent diffusion coefficient of species i into j , D_i^T is the multicomponent thermal diffusion coefficient of species i , M is the local gas mixture molecular weight, and M_i is the molecular weight of species i . The Stefan-Maxwell (Reference 6) relations may also be used to express j_i ,

$$\frac{\partial x_i}{\partial y} = \sum_j \frac{x_i x_j}{\rho D_{ij}} \frac{j_j + D_j^T \frac{\partial \ln T}{\partial y}}{K_j} - \frac{j_i + D_i^T \frac{\partial \ln T}{\partial y}}{K_i} \quad (2-7)$$

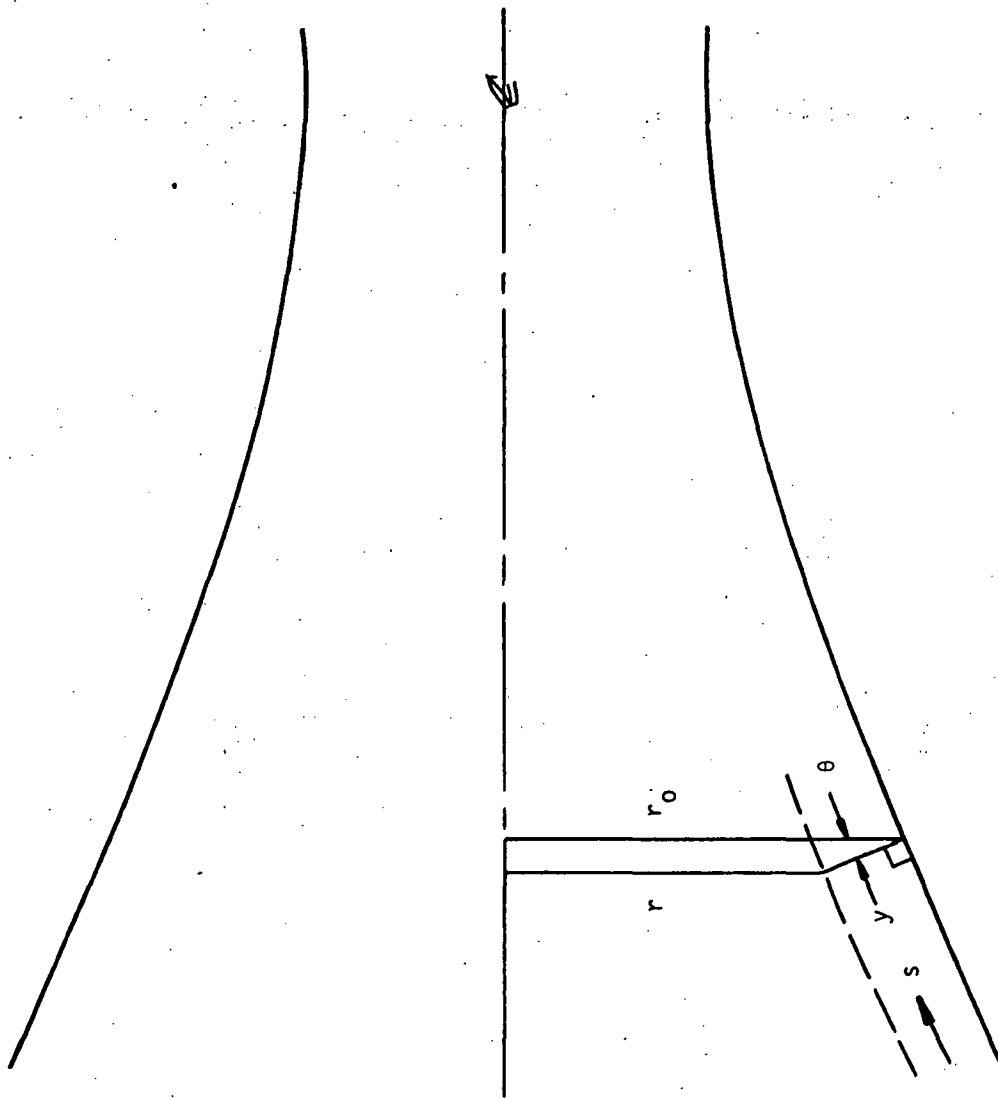


Figure 2-1. Coordinate system.

where x_i is the mole fraction of species i and D_{ij} is the binary diffusion coefficient of species i into j . Both of these expressions are complex in that the multi-component diffusion coefficients are difficult to evaluate, and the Stefan-Maxwell relations provide only implicit expressions for the j_i . For the special case when all diffusion coefficients can be assumed equal and thermal diffusion can be ignored, Fick's law results:

$$j_i = - \rho D \frac{\partial x_i}{\partial y} \quad (2-8)$$

This technique is not used in this analysis.* A further simplification is used to work in terms of "elemental" conservation rather than species conservation. The term "element" is used to refer to those atoms or groupings of atoms which according to equilibrium relations are conserved. Reference 7 discusses the merits of this approach in more detail. Defining α_{ki} as the mass fraction of "element" k in species i , multiplying the species equations (Equation (2-5)) by α_{ki} , and summing over all species results in the following conservation of "elements" equations:

$$\rho u \frac{\partial \tilde{K}_k}{\partial s} + \rho v \frac{\partial \tilde{K}_k}{\partial y} = \frac{1}{r^k} \frac{\partial}{\partial y} \left[r^k \left(\rho \epsilon_D \frac{\partial \tilde{K}_k}{\partial y} - j_k \right) \right] + \sum_i \alpha_{ki} \psi_i \quad (2-9)$$

where \tilde{K}_k is the mass fraction of "element" k in the system defined by

$$\tilde{K}_k = \sum_i \alpha_{ki} K_i \quad (2-10)$$

It has also been assumed that all $\epsilon_{Di} = \epsilon_D$. The "elemental" approach results in significantly fewer simultaneous equations than the conservation of species approach, and the equating of all ϵ_{Di} gives sufficiently accurate solutions for most types of problems. The term $\sum_i \alpha_{ki} \psi_i$ in Equation (2-9) is the production of "element" k which for equilibrium chemistry is set to zero. (For nonequilibrium chemistry the production terms can be non-zero. By retaining the production term in this conservation equation, the same formulation can be used for equilibrium or nonequilibrium chemistry by the simple expedient of setting the production terms to zero for equilibrium conditions.)

*An option is available in the BLIMP program which reduces to Fick's law; however, the program is written to retain the more complex bifurcation approximation to be discussed later in this section.

The streamwise momentum equation can be written as

$$\rho u \frac{\partial u}{\partial s} + \rho v \frac{\partial u}{\partial y} = \frac{1}{r^\kappa} \frac{\partial}{\partial y} \left[\rho r^\kappa (v + \epsilon_M) \frac{\partial u}{\partial y} \right] - \frac{\partial P}{\partial s} \quad (2-11)$$

where P is the local static pressure, and the eddy viscosity ϵ_M is defined in terms of the Reynolds' stresses of turbulent flow by

$$\rho \epsilon_M = - \frac{(\rho v)'u'}{\frac{\partial u}{\partial y}} \quad (2-12)$$

The transverse direction momentum equation reduces to zero when longitudinal curvature effects are ignored.

The energy equation for this general chemistry boundary layer is

$$\begin{aligned} \rho u \frac{\partial H_T}{\partial s} + \rho v \frac{\partial H_T}{\partial y} = & \frac{1}{r^\kappa} \frac{\partial}{\partial y} \left[\rho r^\kappa (\epsilon_M + v) \frac{\partial u^2/2}{\partial y} + r^\kappa (\lambda + \rho \epsilon_H \bar{c}_p) \frac{\partial T}{\partial y} \right. \\ & + r^\kappa \sum_i \left(\rho \epsilon_D \frac{\partial K_i}{\partial y} - j_i \right) h_i \\ & \left. - \frac{r^\kappa RT}{\rho} \sum_i \sum_j \frac{x_j D_i^T}{m_i D_{ij}} \left(\frac{j_i}{K_i} - \frac{j_j}{K_j} \right) + r^\kappa q_r \right] \end{aligned} \quad (2-13)$$

where H_T is the total enthalpy (static plus kinetic)

$$H_T = h + \frac{u^2}{2} \quad (2-14)$$

h is the static enthalpy including chemical as well as sensible contributions

$$h = \sum_i K_i h_i \quad (2-15)$$

h_i is the static enthalpy of species i given by

$$h_i = \int_{T_0}^T c_{p_i} dT + h_i^0 \quad (2-16)$$

T is the temperature, h_i^0 is the heat of formation of species i at the reference temperature T^0 , c_{p_i} is the specific heat of species i , \bar{c}_p is the frozen specific heat of the gaseous mixture defined as

$$\bar{c}_p = \sum_i K_i c_{p_i} \quad (2-17)$$

λ is the thermal conductivity, R is the universal gas constant, x_j is the mole fraction of species j , and the turbulent enthalpy transport coefficient is defined by

$$\rho \epsilon_H = - \frac{\sum_i K_i (\rho v)'' h_i''}{\sum_i K_i (\partial h_i / \partial y)} \quad (2-18)$$

In the energy equation, as in the species conservation equations, it is necessary to evaluate molecular diffusion flux j_i . As discussed earlier, the general expressions for these terms are difficult to work with, therefore an approximate technique for multicomponent diffusion has been derived. A bifurcation approximation introduced by Bird (Reference 8) and discussed in detail by Bartlett, et al. (References 9 and 10) permits explicit solution of the Stefan-Maxwell relations (Equation (2-7)) for j_i in terms of gradients and properties of species i and of the system as a whole.* In this procedure, the binary diffusion coefficient D_{ij} is approximated by the function

$$D_{ij} \approx \frac{\bar{D}(T, P)}{F_i F_j} \quad (2-19)$$

where \bar{D} is a reference diffusion coefficient and F_i is a diffusion factor for species i . The F_i are determined for a given chemical system by a least squares curve-fit of actual diffusion data. The accuracy of the approximation was found to be very

*The bifurcation approximation is introduced at this point to allow completion of the development of the governing equations. The evaluation of \bar{D} and the F_i to establish the diffusion coefficients will be discussed in Section 2.3.

good (within 5 percent for most cases, Reference 9) and the F_i were observed to be very weak functions of temperature. (They are assumed to be independent of temperature in the BLIMP code.) The multicomponent thermal diffusion coefficients, D_i^T can be approximated by

$$D_i^T = \frac{C_t \rho \bar{D} \mu_2}{\mu_1 \bar{m}} (Z_i - K_i) \quad (2-20)$$

which represents a generalization of a correlation of binary diffusion data (Reference 9). With the aid of these approximations the Stefan-Maxwell equations can then be solved explicitly (Reference 9) for the diffusive flux. The following definitions are introduced for simplicity.

$$\begin{aligned} Z_i &\equiv \frac{m_i x_i}{F_i \mu_2} & \mu_4 &\equiv \ln(\mu_2 T^{C_t}) \\ \bar{Z}_k &= \sum_i \alpha_{ki} Z_i & c_t &\approx -0.5 \\ \mu_1 &\equiv \sum_j x_j F_j & \bar{C}_p &\equiv \sum_i Z_i C_{p_i} \\ \mu_2 &\equiv \sum_j \frac{m_j x_j}{F_j} & \bar{h} &\equiv \sum_i Z_i h_i \\ \mu_3 &\equiv \sum_i \frac{Z_i}{m_i} \end{aligned} \quad (2-21)$$

The species and "elemental" laminar flux relations can thus be expressed as

$$j_i = - \frac{\rho \bar{D} \mu_2}{\mu_1 \bar{m}} \left[\frac{\partial Z_i}{\partial y} + (Z_i - K_i) \frac{\partial \mu_4}{\partial y} \right] \quad (2-22)$$

$$j_k = - \frac{\rho \bar{D} \mu_2}{\mu_1 \bar{m}} \left[\frac{\partial \bar{Z}_k}{\partial y} + (\bar{Z}_k - \bar{K}_k) \frac{\partial \mu_4}{\partial y} \right] \quad (2-23)$$

In addition, the diffusive energy flux terms in Equation 2-13) can be expressed as:

$$\begin{aligned}
q_a = - \left\{ \rho(\epsilon_M + v) \frac{\partial(u^2/2)}{\partial y} + (\lambda + \rho\epsilon_H \bar{c}_p) \frac{\partial T}{\partial y} + \rho\epsilon_D \left(\frac{\partial h}{\partial y} - \bar{c}_p \frac{\partial T}{\partial y} \right) \right. \\
+ \frac{\rho \bar{D} \mu_2}{\mu_1 \bar{m}} \left[\frac{\partial \tilde{h}}{\partial y} - \left(\tilde{c}_p + \frac{c_t^2 R}{\mu_1 \mu_2} \right) \frac{\partial T}{\partial y} + c_t RT \frac{\partial \mu_3}{\partial y} \right. \\
\left. \left. + (\tilde{h} - h + c_t RT \mu_3) \frac{\partial \mu_4}{\partial y} \right] \right\} \quad (2-24)
\end{aligned}$$

The "elemental" species conservation equation becomes

$$\rho u \frac{\partial \tilde{K}_k}{\partial s} + \rho v \frac{\partial \tilde{K}_k}{\partial y} = \frac{1}{r^k} \frac{\partial}{\partial y} \left[r^k \left(\rho \epsilon_D \frac{\partial \tilde{K}_k}{\partial y} - j_k \right) \right] \quad (2-25)$$

and the energy equation can be expressed as

$$\rho u \frac{\partial H_T}{\partial s} + \rho v \frac{\partial H_T}{\partial y} = \frac{1}{r^k} \frac{\partial}{\partial y} [r^k (-q_a + q_r)] \quad (2-26)$$

If equal diffusion coefficients are assumed, $\mu_3 = 1/\bar{m}$, $\tilde{c}_p = \bar{c}_p$, and $\tilde{h} = h$. When thermal diffusion is to be neglected, $c_t = 0$ and $\mu_4 = \ln \mu_2$.

Equations (2-4), (2-11), (2-25), and (2-26) comprise the boundary layer conservation equations, including the approximations for unequal thermal and multicomponent diffusion coefficients of Reference 9. The equations are parabolic in nature, therefore requiring specifications of the dependent variables, their derivatives, or a linear combination thereof along the wall ($y = 0$), the edge of the boundary layer, and at the initial body station. Typical sets of boundary conditions will be discussed later in this section. Also necessary in the mathematical formulation of the problem is the specification of the molecular transport properties, equation of state and equilibrium relations for the multicomponent gas, and a description of the eddy viscosity, conductivity and diffusivity. These will be discussed in the following paragraphs.

2.2 EQUATION OF STATE AND EQUILIBRIUM RELATIONS

The BLIMP program has been formulated in terms of perfect gas behavior of each species.

$$p_i = n_i RT \quad (2-27)$$

The mixture of gases is treated as an ideal gaseous solution. Basically this means that the mixture equation of state can be written as

$$p = \frac{pRT}{M} \quad (2-28)$$

and the mixture thermodynamic state variables can be expressed as

$$\bar{f} = \sum x_i \bar{f}_i = \frac{1}{p} \sum p_i \bar{f}_i \quad (2-29)$$

where f is the property, x_i is the mole fraction of species i , f_i is evaluated at the mixture temperature, and the bar indicates that f is on a mole basis. A complete discussion of gas and condensed phase equilibrium can be found in Reference 7. The following discussion pertains only to the gas phase thermodynamics. The BLIMP code can treat the general equilibrium gaseous system (shifting equilibrium) or a frozen composition "ideal gas".

2.2.1 Chemical Equilibrium

In general, K chemical elements, N_k , in a gas system will interact to form a number of chemical species,* N_i (gas phase). If enough time has elapsed so that thermodynamic and chemical equilibrium is established, the thermodynamic state of the system, including the relative amounts of chemical species present, is completely determined if two independent thermodynamic variables are known in addition to the elemental composition. This condition may be stated mathematically by examining the governing equations for such a system, and showing that the number of independent equations is equal to the number of unknown quantities.

Relations expressing the formation of the gaseous chemical species from the gaseous chemical elements may be written as follows:†

$$\sum_{k=1}^K C_{ki} N_K \rightarrow N_i \quad (2-30)$$

*"Chemical species" as used here includes molecular, atomic, ionic, and electron species.

†It should be noted that it is not strictly necessary to write these reactions in terms of elements. Rather, an independent set of "base" species may be selected. The base species must be selected so that no reaction can be written wherein the reactants and the products are all base species. The formulation presented here is unchanged with the exception that elements are taken to mean base species. For a complete discussion of base species see Reference 7.

In the above, C_{ki} represents the number of atoms of element k in a molecule of species i . At equilibrium, the second law requires that these independent reactions occur without change in free energy, i.e., the free energy of the reactants equals the free energy of the products. Mathematically this is

$$\sum_k C_{ki} G_k = G_i \quad (2-31)$$

where the G_i are the partial molar free energies of the species (also referred to as the chemical potentials). The free energy of species i at the mixture temperature and partial pressure, P_i , can be related to the standard state free energy G_i^0 , which is; the free energy of the species at the same temperature but undiluted and at one atmosphere pressure, by the relation

$$G_i - G_i^0 = \int_{P^0}^P \bar{V}_i dP_i \quad (2-32)$$

where P^0 is one atmosphere. For a gas obeying the perfect gas law ($\bar{V}_i = RT/P_i$) this becomes

$$G_i - G_i^0 = RT \ln P_i \quad (2-33)$$

where P_i , the partial pressure of species i , is in units of atmospheres.

Substitution of Equation (2-33) for G_i and G_k into Equation (2-31) yields

$$\frac{-\Delta G_i^0}{RT} = \ln P_i - \sum_k C_{ki} \ln P_k \quad (2-34)$$

where the standard-state free energy change of the formation reaction for species i is defined by

$$\Delta G_i^0 = G_i^0 - \sum_k C_{ki} G_k^0 \quad (2-35)$$

The term $-\Delta G_i^0/RT$ is the equilibrium constant ($\ln K_{p_i}$) for the formation reaction of species i . The standard-state free energy is a function of temperature only and is obtained for each molecular species from

$$G_i^0 = \bar{h}_i^0 - T\bar{s}_i^0 \quad (2-36)$$

where enthalpies are obtained relative to some chemical base state, often the elements in their most natural form at 298°K and one atmosphere (JANNAF base state). (The curve fit constants for the evaluation of \bar{h}_i^0 and \bar{s}_i^0 are part of the BLIMP input.)

For each chemical element introduced into the system, the conservation of atoms dictates that the amount of any element k in the gas (regardless of molecular configuration) must sum to the total amount of element k in the system. Mathematically, this may be written, for each element k , as

$$\begin{array}{l} \text{Mass fraction} \\ \text{of element } k \\ \text{input to the} \\ \text{system} \end{array} = \frac{m_k}{\bar{m}P} \sum_{i=1}^I c_{ki} P_i \quad (2-37)$$

where \bar{m} is the mixture molecular weight defined by

$$\bar{m} = \sum_{i=1}^I \frac{P_i}{P} m_i \quad (2-38)$$

In addition, there exists the requirement that the partial pressures must sum to the total system pressure

$$\sum_{i=1}^I P_i = P \quad (2-39)$$

Also, mixture thermodynamic properties, such as specific enthalpy, are related to the species concentrations by equations of the form

$$h = \frac{1}{\bar{m}P} \sum_{i=1}^I P_i \bar{h}_i \quad (2-40)$$

Consider now the number of independent equations for the system. The number of gas phase equilibrium relations (Equation 2-34) is equal to the number of gas phase species I minus the number of elements K (because Equations (2-34) are trivial when $i=k$). Note that the system temperature is contained implicitly in Equations (2-34) through the temperature dependence of the equilibrium constants. There are K conservation of elements equations (Equations (2-37)), one for each atomic element introduced into the system. The requirement that the partial pressures sum to the system pressure (Equation (2-39)) contributes one additional equation. For any additional thermodynamic properties of the mixture (enthalpy, entropy, etc.), there exist equations such as Equation (2-40).

Consider next the variables appropriate to this formulation of the problem. The relative concentrations of the I species in the gas phase are given by the P_i 's ($P_i = x_i P$). In this formulation, the composite system molecular weight, \bar{M} is also a variable. There are one each of the mixture thermodynamic variables T , P , h , s , etc. The number of variables and available independent equations may be summarized as

Variables	No. of Such Variables	Equation Number	No. of Such Equations
P_i	I	(2-34)	$I - K$
\bar{M}	1	(2-37)	K
P	1	(2-39)	1
T	1		
h, s, ρ, \dots	n	of the type (2-40)	n
Total Variables	$L+n+3$	Total Equations	$I+n+1$

Thus, there are two less equations than there are variables; and so, if two independent variables are specified (e.g., P and h) in addition to the elemental composition, then closure is obtained and the chemical and thermodynamic state of the system may, in principle, be determined.

2.3 TRANSPORT PROPERTIES

In addition to the thermochemical state properties discussed in the previous section, the program requires mixture transport properties. These include the species diffusion coefficients, mixture viscosity and thermal conductivity. These transport properties are calculated from expressions which are derived from simple kinetic theory and the particular multicomponent diffusion representation previously discussed in Section 2.1. The development of these expressions is discussed in detail in Reference 9. A brief summary of this development and the resulting expressions, are presented in this section. (It should be noted that the accuracy of the approximations used here has reduced impact for turbulent flows since the transport mechanisms are predominantly turbulent.)

2.3.1 Diffusion Coefficients

In Section 2.1 a bifurcation approximation for binary diffusion coefficients was mentioned. This characterizes multicomponent diffusion phenomena with reasonable accuracy without unduly complicating the system of equations to be solved. This simplification is achieved through a correlation for binary diffusion coefficients of the form

$$D_{ij} = \frac{\bar{D}}{F_i F_j} \quad (2-41)$$

where \bar{D} is a reference diffusion coefficient and the F_i are diffusion factors. The essential elements in this approximation, which impact not only the diffusion coefficients but also the viscosity and thermal conductivity, as will be seen later, are the F_i 's and \bar{D} . The correlations given below have been built into BLIMP.

$$\bar{D} = \frac{1.719 \times 10^{-5}}{P} (T)^{1.659} \frac{\text{cm}^2}{\text{sec}} \quad (2-42)$$

where T is in degrees Kelvin and P is in atmospheres.

$$F_i = \left(\frac{M_i}{26.7} \right)^{0.489} \quad (2-43)$$

It has also been found that self-diffusion can be better represented if a different correlation is used. Accordingly, D_{ii} is given by

$$D_{ii} = \frac{\bar{D}}{G_i^2} \quad (2-44)$$

where

$$G_i = \left(\frac{M_i}{24.3} \right)^{0.454} \quad (2-45)$$

For most gas systems these correlations are within 5 percent of more exact values for temperatures on the order of 3000°K. For greater accuracy the values of the F_i and G_i can be calculated, as described in Reference 10, for the specific gas system and temperature range. The resulting values can then be directly input into BLIMP (see Section 5.2, Group 12). The calculations of the mixture viscosity and thermal conductivity are based on the diffusion factors given by Equations (2-41) and (2-44). These will be discussed in the following paragraphs.

2.3.2 Mixture Viscosity

The expression employed by the BLIMP program to calculate the mixture viscosity derives from rigorous first order kinetic theory (Reference 6), subject to a few simplifying assumptions, as discussed in Reference 9. This is the Buddenberg-Wilke mixture formula and is given by:

$$\mu_{mix} = \sum_{i=1}^I \left[\frac{x_i \mu_i}{x_i + 1.385 \frac{RT \mu_i}{P m_i} \sum_{\substack{j=1 \\ j \neq i}}^I \frac{x_j}{D_{ij}}} \right] \quad (2-46)$$

where μ_i is the viscosity of the pure species i . The μ_i may be expressed in terms of the self-diffusion coefficients D_{ii}

$$\mu_i = \frac{5}{6 A_{ii}^*} \frac{P m_i}{RT} D_{ii} \quad (2-47)$$

where A_{ii}^* is a ratio of collision integrals based on a Lennard-Jones intermolecular potential. Substituting Equations (2-41), (2-44), and (2-47) into Equation (2-46) results in the following expression for the viscosity of the multicomponent mixture.

$$\mu_{mix} = \frac{\rho \bar{D}}{\mu_1} \sum_{i=1}^I \left[\frac{\frac{x_i m_i}{F_i \bar{m}}}{1.385 + \frac{x_i F_i}{\mu_1} \left(\frac{6 A_{ii}^* G_i^2}{5 F_i^2} - 1.385 \right)} \right] \quad (2-48)$$

This is the expression utilized to calculate the mixture viscosity in BLIMP.

2.3.3 Mixture Thermal Conductivity

The thermal conductivity in a polyatomic gas mixture may be represented by (Reference 11)

$$k_{mix} = k_{mono-mix} + k_{int} \quad (2-49)$$

where $k_{mono-mix}$ is the thermal conductivity in a mixture computed by neglecting all internal degrees of freedom and k_{int} is the contribution to the thermal conductivity of the mixture due to the internal degrees of freedom of the molecules. A simplified expression for the mono-mixture thermal conductivity can be derived in a manner similar to the procedure previously discussed for the mixture viscosity. This simplified expression is (from Reference 9)

A_{ii}^* is currently set to a constant value of 1.13 in BLIMP.

$$k_{\text{mono-mix}} = \sum_{i=1}^I \left[\frac{x_i k_{i \text{ mono}}}{x_i + 1.475 \frac{RT \mu_i}{P \bar{m}_i} \sum_{\substack{j=1 \\ j \neq i}}^I \frac{x_j}{\beta_{ij}}} \right] \quad (2-50)$$

where $k_{i \text{ mono}}$ is the thermal conductivity of the pure species i neglecting all internal degrees of freedom of the molecule. The $k_{i \text{ mono}}$ may be expressed in terms of the μ_i as

$$k_{i \text{ mono}} = \frac{15}{4} \frac{R}{\bar{m}_i} \mu_i \quad (2-51)$$

The contribution to the thermal conductivity from the internal degrees of freedom may be expressed as (from Reference 9)

$$k_{\text{int}} = \sum_{i=1}^I \frac{\rho x_i \frac{\bar{m}_i}{\bar{m}} \left(c_{pi} - \frac{5}{2} \frac{R}{\bar{m}_i} \right)}{\sum_{j=1}^I \frac{x_j}{\beta_{ij}}} \quad (2-52)$$

By combining Equations (2-41) and (2-44) with Equations (2-49) through (2-52), the mixture thermal conductivity may be written as

$$k_{\text{mix}} = \frac{\rho \bar{D}}{\mu_1} \left\{ \sum_{i=1}^I \left[\frac{\frac{15}{4} \frac{x_i R}{\bar{F}_i \bar{m}}}{1.475 + \frac{x_i \bar{F}_i}{\mu_1} \left(\frac{6A_{ii}^* G_i^2}{5F_i^2} - 1.475 \right)} \right] + \frac{\mu_2}{\bar{m}} \left[\tilde{c}_p - \frac{5}{2} R \mu_3 \right] \right\} \quad (2-53)$$

where μ_1 , μ_2 , μ_3 , and \tilde{c}_p are given by Equations (2-21). Thus, Equation (2-53) is the expression utilized to calculate the mixture thermal conductivity in BLIMP. Also calculated for use in the solution procedure and as output are the Prandtl and Schmidt numbers which are defined here as

$$Pr = \frac{\mu}{k} C_{p-frozen} \quad (2-54)$$

$$\overline{Sc} = \frac{\mu_1 \mu_m}{\mu_2 \rho \overline{D}} \quad (2-55)$$

2.4 SIMPLIFIED MODELS FOR THERMODYNAMIC AND TRANSPORT PROPERTIES

2.4.1 Nonreacting Gas

It may be desired to suppress chemical equilibrium and specify the species composition of the mixture. This option is available in the BLIMP program. In this case the mixture properties are calculated from Equations (2-38), (2-39), and (2-40) where the P_i are specified through the mixture composition. (Although this approach sacrifices some of the generality of the program it results in shorter computation times.) In this case the mixture transport properties are directly input as explicit expression for the mixture viscosity and mixture Prandtl number as functions of the temperature.

This option eliminates the equilibrium chemistry solutions at each node, eliminates any diffusion considerations, and eliminates the necessity to include the species equations in the set of equations to be solved.

2.4.2 Binary Diffusion Approximation

A significant savings in computation time can be made by reducing the number of equations to be solved. In Section 2.4.1 this was done by simplifying the chemistry and transport properties calculations. If it is desired to retain the general chemistry option it is still possible to reduce the computation time by reducing the number of species equations to two. The procedure applies to gas systems containing three or more elements. The simplification is made by grouping the elements into two groups which are then considered to diffuse into each other; hence, binary diffusion. The use of this option is discussed in Section 6.4. In many cases where the elements in each group have roughly the same molecular weight this approximation introduces very little inaccuracy into the boundary layer solution procedure.

2.5 TURBULENT FLOW CONSIDERATIONS

In the conservation equations developed previously, the concepts of eddy viscosity, eddy diffusivity, and eddy conductivity were used to express the correlations of fluctuating velocity, species, and enthalpy fields in terms of mean field quantities. This is only one of several possible techniques of closing the set of equations (assuming satisfactory expressions for the eddy parameters are available), and it does not provide any information regarding the evolution of the turbulent correlations as the flow progresses downstream. Admittedly, it would be more desirable to describe the turbulent fluctuations in a more complete manner such as with an entrainment relation, turbulent kinetic energy relation, or a local turbulent constitutive equation (Reference 12). However, these techniques are still in early stages of development even for incompressible single component flows, therefore a more proven approach was selected for the present analysis. The Boussinesq description of turbulent boundary layers has proved to be very useful, particularly for complex reacting flows such as are being described here, and will be used exclusively in the present analysis.

There is a wide amount of latitude possible even within the eddy viscosity framework of turbulence, particularly in applying classical incompressible models to compressible flows. The following subsections describe the turbulence models currently built into BLIMP. The three models are those of Kendall (Reference 13) Bushnell and Beckwith (References 14 and 15), and Cebeci and Smith (References 16 and 17). The JANNAF standardized prediction procedure uses the Kendall model.

2.5.1 General Features

Boussinesq's eddy viscosity concept is adapted to write the Reynolds stresses as

$$-\overline{(\rho v)'u'} = \rho \epsilon_m \frac{\partial u}{\partial y} \quad (2-56)$$

and a similar relation is used to define eddy conductivity, ϵ_h^*

$$-\overline{(\rho v)'T'} = \rho \epsilon_h \frac{\partial T}{\partial y}$$

All three models in the present discussion employ the Prandtl mixing length hypothesis in which it is assumed that

$$\epsilon_m = \ell v_t \quad (2-57)$$

* This is a simplified form of Equation (2-18)

where ℓ is the mixing length and v_t is the turbulent velocity. The differences between the three models come about through the formulation of ℓ and v_t . Kendall and Cebeci treat the boundary layer as a composite layer consisting of inner and outer regions. In the inner, or wall, region the turbulent velocity is written as

$$v_t = \ell \left| \frac{du}{dy} \right| \quad (2-58)$$

and the mixing length is assumed to be proportional to the distance from the wall. In the outer, or wake, region the boundary layer is assumed to behave similarly to free turbulent shear flow with $v_t = u_e$, the free stream velocity, and $\ell = c\delta^*$ where c is a constant and δ^* is a boundary layer characteristic thickness taken as the velocity defect thickness. Thus,

$$\epsilon_m = cu_e \delta^* \quad (2-59)$$

where

$$\delta^* = \int_0^\infty \left(1 - \frac{u}{u_e} \right) dy \quad (2-60)$$

Bushnell and Beckwith, however, treat the boundary layer as a single layer and apply Equation (2-57) throughout by introducing the intermittency concept in the definition of ℓ . The most fundamental differences in the models arise, however, from the manner in which the mixing length expression is obtained. The Cebeci and Bushnell expressions originate from Prandtl's proposal that in the region of the development of turbulence

$$\frac{d\ell}{dy} = k \quad (2-61)$$

which has as a solution

$$\ell = ky \quad (2-62)$$

The models are arrived at by significant modifications to this solution to account for the effects of variable properties, pressure gradient, Reynolds number, etc. It is important that these modifications were made to the solution and not to the basic proposition as expressed by Equation (2-61). The Kendall model, on the other hand, follows from modifications to the basic proposition to account for the effects of

variable properties (see Equation (2-65)). It has been observed that differences in the models become more pronounced as the degree of property variation increases (Reference 18).

The turbulent transport of scalar quantities is treated the same way as momentum by introducing the concepts of eddy conductivity, ϵ_h , and eddy diffusivity, ϵ_D . Turbulent Prandtl and Schmidt numbers are defined as $Pr_t \equiv \epsilon_m / \epsilon_h$ and $Sc_t \equiv \epsilon_m / \epsilon_D$. Cebeci proposes an expression for Pr_t as a function of the distance from the wall but in the Kendall and Bushnell-Beckwith models Pr_t is assumed to be a constant. The turbulent Schmidt number is also taken to be constant in all the models.

2.5.2 Kendall Model

This model employs the two-layer concept of the turbulent boundary layer. The wall law is based on the following three concepts:

- $\lim_{y \rightarrow 0} \ell \rightarrow 0$
- $\lim_{y \rightarrow 0} d\ell/dy = 0$
- Rate of increase of the mixing length with y is proportional to the difference between the value postulated by Prandtl (ky) and its actual value

$$\frac{d\ell}{dy} \sim (ky - \ell) \quad (2-63)$$

The proportionality factor in this relation is assumed to be dependent on the local shear stress and local kinematic viscosity

$$\frac{d\ell}{dy} = (ky - \ell) \frac{\sqrt{\tau/\rho}}{y_a^+ \nu} \quad (2-64)$$

where y_a^+ is a constant. The values of the constants k and y_a^+ recommended in this model are 0.44 and 11.823, respectively. These constants have been obtained by matching the predictions with experimental data in incompressible turbulent boundary layers with and without blowing (Reference 13). (Physically k can be considered as a measure of the rate of growth of the mixing length with respect to distance from the wall and y_a^+ is a measure of the thickness of the laminar sublayer.) The validity of the model for flows with wall blowing and streamwise pressure gradient is argued on the basis of using the local flow properties, such as local shear, in the model.

For compressible flow, the wall law is modified as follows:

$$\frac{d\rho\ell}{dy} = \left[k \int_0^y \rho dy - \rho\ell \right] \frac{\sqrt{\tau/\rho}}{y_a^+ v} \quad (2-65)$$

where, instead of describing the length scale of a turbulent eddy, the mass of the eddy, $\rho\ell$, is related to the mass available between the wall and the point of interest. The constants k and y_a^+ , however, are left at their incompressible values. The above integral-differential equation is solved numerically to obtain the local value of the mixing length ℓ .

In the wake region, it is assumed that the eddy viscosity is a constant and is given by Clauser's expression (Equation (2-59)) where $c = 0.018$. The wall and the wake regions are matched by the following procedure: the ϵ_m expression for the wall region is used until it exceeds the wake value at which point the wake value of ϵ_m is used for the remainder of the boundary layer thickness. This value is linearly damped in the outer-portions of the boundary layer so that a value of zero occurs at the boundary layer edge.

2.5.3 Cebeci-Smith Model

As it was mentioned previously, a two-layer model is also used by Cebeci and Smith. In the inner (wall) region, the Van Driest (Reference 19) form of mixing length is now used:

$$\ell = k_m y [1 - \exp(-y^+/A^+)] \quad (2-66)$$

where

$$y^+ = \frac{y\sqrt{\tau_w/\rho}}{\nu}$$

Van Driest suggested constant values of 0.4 and 26 for the k_m and A^+ , respectively. (These have essentially the same meaning as k and y_a^+ .) In the Cebeci model, however, these constants are replaced by functions accounting for pressure gradient and blowing. Compressibility effects are also accounted for by using local values for μ and ρ .

For flows with pressure gradient and mass transfer, Cebeci replaced the wall shear in the damping parameter by τ_s which he obtained from the simplified form of the momentum equation in the sublayer (Reference 16):

$$\frac{d\tau_s}{dy} - \frac{v_w}{v_w} \tau_s = \frac{dp}{dx} \quad (2-67)$$

The solution of this equation at $y^+ = 11.8$ results in

$$A^+ = A \left\{ -\frac{p^+}{v_w^+} [\exp (11.8 v_w^+) - 1] + \exp (11.8 v_w^+) \right\}^{-1/2} \quad (2-68)$$

where

$$p^+ = -\frac{dp}{dx} \frac{v}{\rho_w u_\tau^3}, \quad v_w^+ = \frac{v_w}{u_\tau}, \quad u_\tau = \sqrt{\frac{\tau_w}{\rho}} \quad (2-69)$$

and $A = 26$.

Following Van Driest's approach to arrive at the mixing length formulation with a damping factor in the inner region, Cebeci derived the following expression for eddy conductivity:

$$\epsilon_h = k_m k_h y^2 [1 - \exp (-y^+/A^+)] [1 - \exp (-y^+ \sqrt{Pr}/B^+)] \left| \frac{\partial u}{\partial y} \right| \quad (2-70)$$

where

$$B^+ = B \left\{ -\frac{p^+}{v_w^+} [\exp (11.8 v_w^+) - 1] + \exp (11.8 v_w^+) \right\}^{-1/2} \quad (2-71)$$

and $k_h = 0.44$, $B = 34$.

Cebeci (Reference 17) further argued that the above values of k_m , k_h , A , and B are only satisfactory for large Reynolds number ($Re_\theta > 6000$) and he proposed function of Re_θ for k_m , k_h , A , and B . There is some question as to the validity of the Re_θ dependence, particularly for compressible flows in nozzles. Furthermore, the model is completely adequate without this dependence.* For these reasons the constant values of k_m , k_h , A , and B are used. (The values of these constants were established by correlation with incompressible flow data.)

The turbulent Prandtl number ($Pr_t \equiv \epsilon_m/\epsilon_h$) is obtained from Equations (2-57), (2-58), (2-66), and (2-72);

* Personal communication: Tuncer Cebeci, McDonnell-Douglas, Long Beach, California.

$$Pr_t = \frac{k_m [1 - \exp(-y^+/A^+)]}{k_h [1 - \exp(-y^+ \sqrt{Pr/B^+})]} \quad (2-72)$$

Although Equations (2-66) and (2-70) are valid only in the boundary layer inner region, Cebeci shows that Equation (2-72) agrees satisfactorily with experimental data of References 20, 21, 22, and 23 throughout the boundary layer and, hence, it is so used.

In the wake region, Cebeci uses the Clauser expression for eddy viscosity, Equation (2-59) with $c = 0.0168$. This expression is damped in the same way as in the Kendall model.

2.5.4 Bushnell-Beckwith Model

The Bushnell-Beckwith model is a single layer model which reduces to the Van Driest form of mixing length near the wall and is modified in the outer region by an intermittency factor γ (Reference 24). The mixing length expression is written as:

$$\frac{\lambda}{\delta} = K [1 - \exp(-y^+/A^+)] f(y/\delta) \gamma^{1/2} \quad (2-73)$$

where

$$\gamma = \frac{1 - \operatorname{erf} [5(y/\delta - 0.78)]}{2} \quad (2-74)$$

and

$$f(y/\delta) = \tanh \left(\frac{k_m}{K} \frac{y}{\delta} \right) \quad (2-75)$$

and the constants are: $k_m = 0.4$, $K = 0.08$, $A^+ = 26$. The boundary layer thickness δ appearing in Equations (2-73), (2-74), and (2-75) is defined as the distance normal to the wall where the velocity ratio $(u/u_e) = 0.995$.

The present model has been tested against experimental data by Bushnell and Beckwith (Reference 25). In their work, however, they use a different function than the one given by Equation (2-75). They assume that $f = y/\delta$ in the inner wall region, $y/\delta \leq 0.1$, and it is a function of the incompressible shape factor ($H \equiv \delta^*/\theta$) in the far wall region, $y/\delta \geq 0.3$. The values of f in the far wall region are obtained from a curve fit to experimental data of λ/δ versus H . In the interval, $0.1 < y/\delta < 0.3$, a straight line is used to join the inner and far wall regions. Based on this model, Bushnell and Beckwith compared their predictions of flows with blowing and pressure gradient with experimental data of References 26 and 27. They

report (Reference 25) that in the application of the model to flows with wall blowing, the effect of blowing could be accounted for only when the wall damping factor of Van Driest, A^+ , was made an experimentally based function of the blowing rate. The present functional form of f , Equation (2-75), is based on the recommendation of Harris.*

As noted by Harris (Reference 15), based on the available data, there exists a lack of conclusiveness as to how the turbulent Prandtl number should be formulated in terms of local boundary layer parameters under different flow conditions. Therefore, a constant value of 0.9 is used for Pr_t in this model.

2.5.5 Boundary Layer Transition

Transition from laminar to turbulent flow can be specified in two ways. In the first when a user specified value of Re_θ is exceeded the turbulent transport properties are introduced into the calculations; however, they are reduced by a scale factor varying between 0 and 1 to simulate a transition zone. Thus

$$\epsilon = I(s) \epsilon_{(model)}$$

where

$$\begin{aligned} I(s) &= \frac{S}{S_t} - 1 & S_t \leq S \leq 2S_t \\ I(s) &= 0 & S < S_t \\ I(s) &= 1 & S \geq 2S_t \end{aligned} \quad (2-76)$$

and S_t is the value of S (streamwise coordinate) at which the transition criteria is exceeded.

In the second method, transition is activated at a user specified position. In this case there is no transition zone.

2.6 BOUNDARY CONDITIONS

The usual set of boundary conditions for the boundary layer flow problem consists of the specification of initial profiles for the dependent variables f' , H_T , and \tilde{K}_k , plus additional specifications of these quantities along the wall and at the edge of the boundary layer, and the specification of f_w along the wall. However, these boundary conditions have been greatly generalized to include flows such

*Personal communication.

as transpiration cooling and ablation. The numerous options resulting from this generalization are discussed below.

The boundary layer edge conditions typically are found from an isentropic expansion from known elemental gas composition and stagnation conditions. Thus, given a set of stagnation conditions and a description of local static pressure along the surface of interest, the techniques of Reference 7 may be used to establish the entropy of the gaseous mixture which, when combined with the specified pressures, can be used to establish the complete equilibrium edge gas state at each body station. That is, the total enthalpy, edge velocity, edge pressure, and edge species concentrations can be determined. The boundary conditions would then consist of

$$\begin{aligned} u_{\text{edge}} &= u_{\text{edge/expansion}} \\ H_{T_{\text{edge}}} &= H_{T_{\text{edge/expansion}}} \\ \tilde{K}_{k_{\text{edge}}} &= \tilde{K}_{k_{\text{edge/expansion}}} \end{aligned} \quad (2-77)$$

An additional constraint at the boundary layer edge which is necessary only when cubics are used to represent the profiles is the requirement of zero slope, i.e.,

$$\begin{aligned} \left. \frac{du}{dy} \right|_{\text{edge}} &= 0 \\ \left. \frac{dH_T}{dy} \right|_{\text{edge}} &= 0 \\ \left. \frac{d\tilde{K}_k}{dy} \right|_{\text{edge}} &= 0 \end{aligned} \quad (2-78)$$

It is also possible to input the edge velocity rather than calculate it by isentropic expansion. In this case the edge thermodynamic state is calculated from the input pressure, input elemental composition, and the static enthalpy calculated from

$$h = H_T - \frac{1}{2} u_{\text{edge}}^2 \quad (2-79)$$

The resulting boundary conditions are the same as those of Equations (2-77).

Initial profiles of velocity, total enthalpy, and elemental concentration are more difficult to establish for the general problem, therefore calculations are often started with reasonable assumed profiles far upstream of the region of interest so that effects of erroneous assumptions will die out. Another possibility is to

assume a similar solution as a starting profile. This assumption reduces the equations to ordinary differential equations at the starting point, which may be solved simultaneously for a set of profiles unique to the assumed edge and wall state. This is the most common method of establishing initial profiles. (The user may supply a starting profile or use the similarity starting profile, in which case the first guess may be input or generated by the program.)

The wall boundary conditions allow the widest selection of options. The simplest combination is the straightforward assignment of velocities, enthalpy, and elemental concentrations at the wall:

$$\begin{array}{ll}
 u_w = 0 & \text{no slip} \\
 \rho_w v_w = \rho_w v_w |_{\text{input}} & \text{specified } \rho_w v_w \\
 H_{T_w} = h_w (S) & \text{specified enthalpy of gas at the wall} \\
 \tilde{K}_{k_w} = \tilde{K}_{k_w} (\xi) & \text{specified wall gas elemental composition*}
 \end{array} \tag{2-80}$$

Wall temperatures may be used to find wall enthalpy in the above formulation. Also, wall mass diffusive fluxes of up to three individual injectants may be assigned in lieu of \tilde{K}_{k_w} and $\rho_w v_w$. With the values of the dependent variables all directly assigned in this manner, the boundary layer problem is uncoupled from the surface chemistry interaction.

The inclusion of surface material/boundary layer gas interaction chemistry in the boundary layer problem forms the second major set of wall boundary condition options. Using the surface thermochemistry techniques of Reference 7, it is possible to specify given mass fluxes of the (up to) three injectants (or transpirants) at the wall and require chemical equilibrium between the injectants, the wall material, and the adjacent gas stream. In this instance, the values of H_{T_w} (i.e., T_w) and \tilde{K}_{k_w} are found by simultaneous solution of the local surface chemical equilibrium equations, surface mass balances, and the no-slip velocity boundary conditions.

In the use of this boundary layer technique in conjunction with in-depth charring ablation analyses,† the chemically active injectants might result from the pyrolysis of an internally decomposing material, surface material combustion or phase change, and mechanical removal. A variation of this type of wall boundary condition is to specify the wall temperature or enthalpy and allow the surface chemistry

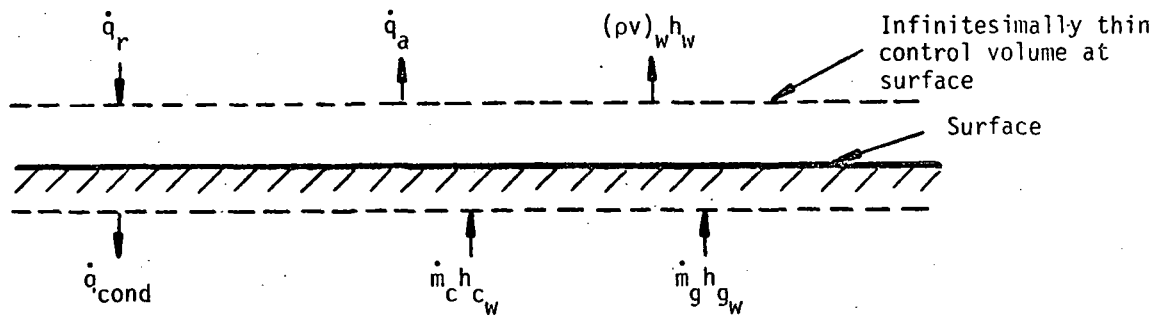
* It is physically unrealistic in most cases to assign \tilde{K}_{k_w} when diffusion coefficients are unequal since the contribution to \tilde{K}_{k_w} by preferential diffusion of the various "elements" to the surface is not known a priori.

† These conditions might apply, for example, in a solid propellant rocket nozzle.

calculations to compute the necessary $\rho_w v_w$ and \tilde{K}_{kw} . In summary, the surface equilibrium wall boundary condition is

$$\begin{aligned}
 u_w &= 0 && \text{no slip} \\
 \rho_w v_w &= \rho_w v_w|_{\text{input}} && \text{specified } \rho_w v_w \\
 f_w &= f_w(\xi) && (2-81) \\
 \left. \begin{aligned} H_{Tw} &= H_{Twequil} \\ \tilde{K}_{kw} &= \tilde{K}_{kwequil} \end{aligned} \right\} &&& \text{from surface equilibrium requirement}
 \end{aligned}$$

The final wall boundary condition category involves the use of a steady state energy balance at the surface.* A general surface energy balance can best be understood by examination of a schematic representation of the energy fluxes to an ablating or nonablating ($\dot{m}_c = 0$) surface:



Summing terms,

$$\dot{m}_g h_{g_w} + \dot{m}_c h_{c_w} - \dot{q}_{a_w} + \dot{q}_{r_w} - (\rho v)_w h_w - \dot{q}_{cond} = 0 \quad (2-82)$$

which is valid in either a transient or steady-state situation. In general, an in-depth charring ablation solution would be needed to provide the conduction term \dot{q}_{cond} and the pyrolysis gas rate, \dot{m}_g . Under steady state conditions, the internal pyrolysis "front" and the charred surface are assumed to be receding at the same rate, therefore requiring that the energy conducted into the wall material must equal the enthalpy rise of the wall material and pyrolysis gases. In equation form

*These conditions might apply to a solid propellant rocket nozzle.

$$\dot{q}_{\text{cond}} - \dot{m}_c (h_{c_w} - h_c^0) - \dot{m}_g (h_{g_w} - h_g^0) = 0 \quad (2-83)$$

Substituting into Equation (2-82), the steady state energy balance becomes

$$-\dot{q}_{a_w} + \dot{q}_{r_w} - (\rho v)_w h_w + \dot{m}_c h_c^0 + \dot{m}_g h_g^0 = 0 \quad (2-84)$$

In this equation, \dot{q}_{a_w} is the wall value of the energy flux defined in Equation (2-24), and is found in the course of the boundary layer solution. The surface equilibrium requirement is always used in conjunction with the steady state energy balance. Therefore, if one specifies the compositions and heats of formation of the pyrolysis gas and char materials, the simultaneous solution of the energy equation above and the surface chemistry relations mentioned earlier completely couples the boundary layer flow to the surface response. The steady state assumption is good even in transient situations for large ablation rates or small thermal diffusivity of the ablation material (Reference 17). In summary, the use of the steady state energy balance results in the following:

$$\begin{array}{ll} u_w = 0 & \text{no slip} \\ H_{T_w} = H_{T_{w,s.s.}} & \text{steady state energy balance} \\ \left. \begin{array}{l} \rho_w v_w = \rho_w v_{w\text{equil}} \\ \tilde{K}_{k_w} = \tilde{K}_{k_{w\text{equil}}} \end{array} \right\} & \text{surface equilibrium requirement} \end{array} \quad (2-85)$$

These are several of the possible wall boundary conditions. Examples of how they are implemented and the types of problem to which they apply are discussed in Section 6.

2.7 SUMMARY OF ASSUMPTIONS

A summary of the assumptions and approximations included in the analysis is given below. This does not include those approximations, such as nonreacting gas, which may be activated but are not inherent to the formulation of the program.

- Quasi-steady flow
- Ideal gas
- Multicomponent diffusion is modeled by the bifurcation approximation. The resulting F_i and G_i coefficients are assumed to be independent of temperature.

- Diffusion introduced by pressure gradients and body forces is neglected.
- Viscosity and thermal conductivity are calculated by the mixture approximations of Buddenberg and Wilke, and Mason and Saxena, respectively.
- Pressure gradients normal to the wall are assumed to be zero. Thus the y momentum equation can be dropped from the set of governing equations.
- Body forces, such as gravity, are not included in the formulation.
- Only gas phase flow is considered.
- There is no model for radiation emitted or absorbed by the gas although the term q_r is retained in the formulation.
- No streamwise changes in edge elemental composition are allowed.
- The turbulent eddy diffusivities are forced to zero at the edge of the boundary layer.
- No gas phase kinetics are included.
- Surface roughness effects not modeled.
- Separation not modeled (adverse pressure gradients are allowed).
- Laminarization of turbulent flows not modeled.

SECTION 3

INTEGRAL MATRIX SOLUTION PROCEDURE

The solution of the boundary layer equations presented in Section 2 uses an integral matrix method which has been developed specifically for the solution of chemically reacting, nonsimilar, coupled boundary layers. A complete presentation of the integral matrix procedure was included in Reference 1, where solution of laminar flow problems was discussed. In the present effort, this technique has remained essentially unchanged, however, new variables and equations have been added to describe the turbulent aspects of the flow. The present discussion will therefore review only the highlights of the method, and the reader may refer to Reference 1 for more details.

The governing equations presented in Section 2 are transformed from the physical plane (s, y) to a new coordinate space (ξ, η) . In the integral matrix procedure, the primary dependent variables and their derivatives with respect to η are related by Taylor series expansions such that these dependent variables are represented by connected quadratics or cubics (either option is available). That is, f' , H_T , and \tilde{K}_k are expanded in Taylor series form and the series are truncated to reflect the proper polynomial representation. A nodal network is defined through the boundary layer and the Taylor series expansions are assumed valid between each set of nodes, with an additional requirement of continuous first and second derivatives (a spline fit) at each node. Primarily for convenience, the conservation equations are integrated across each "strip" (between nodal points) using a unity weighting function. The linear Taylor series expansions together with linear boundary conditions form a very sparse matrix which has to be inverted only once for a given problem. The nonlinear boundary layer equations and nonlinear boundary conditions are then solved by driving the errors to zero using Newton-Raphson iteration.

3.1 COORDINATE TRANSFORMATIONS

The equations of motion for a boundary layer flow can be solved in the physical (s, y) plane by numerous techniques, however, it is sometimes advantageous to transform the problem to another coordinate system. The transformed coordinates offer the advantages of nondimensionalizing the solution, confining the solution to a narrower region, minimizing changes in the dependent variables, and simplifying

boundary conditions and occasionally result in the deletion of streamwise derivative terms. This latter possibility occurs only under very restrictive sets of boundary conditions. The coordinate transformation in the present analysis is a variation of the Levy-Lees transformation and is derived in its entirety in Reference 1. The standard Levy-Lees transformation takes the form

$$\begin{aligned}\hat{\xi} &= \int_0^s \rho_1 u_1 \mu_1 r_0^{2K} ds \\ \hat{\eta} &= \frac{r_0^K u_1}{\sqrt{2\hat{\xi}}} \int_0^y \rho dy\end{aligned}\tag{3-1}$$

The first alteration of this transformation is actually a mathematical convenience for carrying out the numerical solution. Introducing a stretching parameter α_H in the normal coordinate, a new coordinate system is defined by

$$\begin{aligned}\bar{\xi} &= \hat{\xi} \\ \bar{\eta} &= \frac{\hat{\eta}}{\alpha_H}\end{aligned}\tag{3-2}$$

The parameter α_H is taken as a function of $\bar{\xi}$ only and is determined implicitly during the solution. Its purpose is to stretch the $\bar{\eta}$ coordinate such that the boundary layer remains of constant thickness in the $\bar{\eta}$ coordinates.

Since a new variable $\alpha_H(\bar{\xi})$ is introduced, an additional relation is required. This is conveniently supplied by constraining some arbitrary point near the boundary-layer edge, η_c , to have a specified streamwise velocity, c , near (but something less than) the edge value:

$$f' \Big|_{\bar{\eta}_c} = c f' \Big|_{\bar{\eta}_{\text{edge}}}\tag{3-3}$$

where f is the transformed stream function defined as

$$f - f_w = \int_0^{\hat{\eta}} \frac{u}{u_1} d\hat{\eta} = \alpha_H \int_0^{\bar{\eta}} \frac{u}{u_1} d\bar{\eta}\tag{3-4}$$

and the prime denotes differentiation with respect to $\bar{\eta}$ so that

$$f' = \alpha_H \frac{u}{u_1} \quad (3-5)$$

Examples of the utility of the stretching parameter α_H are contained in Reference 1.

The second change in the Levy-Lees transformation has to do with the transverse curvature effect. For very small nozzles, it is possible to have boundary layer thicknesses on the order of the nozzle radius r_0 . In this instance, it is necessary to treat r as a function of y , thereby including its variation through the boundary layer. The coordinate transformations become

$$\xi = \int_0^s \rho_1 u_1 \mu_1 r_0^{2K} ds \quad (3-6)$$

$$\eta = \frac{u_1}{\alpha_H \sqrt{2\xi}} \int_0^y \rho r^K dy$$

Utilization of the above coordinate transformation relations results in a new set of governing equations in the (ξ, η) coordinate plane which will be given below. Primes will hereafter refer to derivatives with respect to η except when noted otherwise.

The global continuity equation is automatically satisfied by the definition of a transformed stream function $f(\xi, \eta)$, shown in Equation (3-4), and re-defined here in the final coordinate system:

$$f - f_w = \alpha_H \int_0^\eta \frac{u}{u_1} d\eta \quad (3-7)$$

where f_w is given by

$$f_w = - \frac{1}{\sqrt{2\xi}} \int_0^\xi \frac{\rho_w v_w}{\rho_1 u_1 \mu_1 r_0^K} d\xi \quad (3-8)$$

The governing equations will be presented below in transformed coordinates. The algebra of the transformation can be found in Reference 1.

Streamwise Momentum Equation (2-11)

$$ff'' + \left[\frac{tC \left(1 + \frac{\epsilon_M}{v} \right)}{\alpha_H} f'' \right]' + \beta_p \alpha_H^2 \frac{\rho'}{\rho} - \beta_v f'^2 = 2 \left(f' \frac{\partial f'}{\partial \ln \xi} - f'^2 \frac{\partial \ln \alpha_H}{\partial \ln \xi} - f'' \frac{\partial f}{\partial \ln \xi} \right) \quad (3-9)$$

In this equation, utilizing the technique of Reference 28, the transverse curvature effect is included entirely in the coordinate transformation and in the definition of t :

$$t = \left(\frac{r}{r_0} \right)^2 = 1 - \frac{2\alpha_H \sqrt{2\xi} \cos \theta}{u_1 r_0^2} \int_0^\eta \frac{1}{\rho} d\eta \quad (3-10)$$

where θ is the angle between the surface normal and a plane normal to the body centerline (see Figure 2-1) and the subscript 1 refers to a reference condition which is normally taken as the edge condition at any streamwise station.

$$C = \frac{\rho \mu}{\rho_1 \mu_1} \quad (3-11)$$

$$\beta_v = 2 \frac{\partial \ln u_1}{\partial \ln \xi} \quad (3-12)$$

$$\beta_p = - \frac{2}{\rho_1 u_1^2} \frac{dP}{d \ln \xi} \quad (3-13)$$

For solutions without consideration of transverse curvature, t is set to 1.0 throughout the boundary layer.

Turbulent Model Equations

The turbulent fluctuations are related to the mean field through the eddy models described in Section 2.5. Eddy viscosity is described by a wall law and a wake law, while eddy diffusivity and conductivity are related to eddy viscosity by turbulent Schmidt and Prandtl numbers:

$$Sc_t = \frac{\epsilon_M}{\epsilon_D}$$

(3-14)

$$Pr_t = \frac{\epsilon_M}{\epsilon_H}$$

Defining

$$\delta = \frac{\sqrt{2\epsilon}}{\rho_1 u_1 r_0^{\kappa}}$$

$$\tilde{\ell} = \frac{\rho \ell}{\rho_1 \delta}$$

$$Re_\delta = \frac{\rho_1 u_1 \delta}{\mu_1}$$

$$\tilde{\epsilon}_M = \frac{\rho^2 \epsilon_M}{\rho_1 \mu_1}$$

The wall region eddy viscosity relation becomes

$$\tilde{\epsilon}_M = \frac{\rho(Re_\delta)}{\rho_1 \alpha_H^2} \tilde{\ell}^2 f'' \quad (\text{wall region})$$

(3-15)

$$\tilde{\epsilon}_M = c \left(\frac{\rho}{\rho_1} \right)^2 Re_{\delta_i^*} \quad (\text{wake region})^*$$

where

$$\delta_i^* = \delta \alpha_H \int_0^\infty \left(1 - \frac{f'}{\alpha_H} \right) \frac{\rho_1}{\rho} d\eta \quad (3-16)$$

Transverse curvature is not considered in determining the wake region length scale δ_i^* .

*The single layer model of Bushnell uses the wall expression throughout. The constant c is typically 0.0168 for the Cebeci mode and 0.018 for the Kendall model.

Energy Equation (2-26)

$$fH_T' + [t(-q_a^* + q_r^*)]' = 2 \left(f' \frac{\partial H_T}{\partial \ln \xi} - H_T' \frac{\partial f}{\partial \ln \xi} \right) \quad (3-17)$$

where q_a^* is the normalized diffusive energy flux away from the surface including turbulent fluxes

$$q_a^* = q_a / \alpha^* \quad (3-18)$$

The flux normalizing parameter α^* is defined by

$$\alpha^* = \frac{\rho_1 u_1 \mu_1 r_0^K}{\sqrt{2\xi}} = \frac{\mu_1}{\delta} \quad (3-19)$$

The diffusive energy flux q_a in the transformed coordinates is defined later in this section.

"Elemental" Species Equations (2-25)*

$$f\tilde{K}_k' + \left[t \left(\frac{\tilde{\epsilon}_M}{\alpha_H Sc_t} \tilde{K}_k' - j_k^* \right) \right]' + \left(\frac{\phi_k}{\rho} \right) \left(\frac{\rho e^\mu e^{\alpha_H}}{\alpha^{*2}} \right) = 2 \left(f' \frac{\partial \tilde{K}_k}{\partial \ln \xi} - \tilde{K}_k' \frac{\partial f}{\partial \ln \xi} \right) \quad (3-20)$$

where j_k^* is the normalized diffusive flux of "element" k

$$j_k^* = j_k / \alpha^* \quad (3-21)$$

Diffusive Fluxes

The normalized diffusive energy flux is given by

* There are $K-1$ such equations for the k "elements". Only $K-1$ of the "elements" are considered as unknowns since the K^{th} "element" is given by

$$\tilde{K}_K = 1 - \sum_{k=1}^{K-1} \tilde{K}_k$$

$$\begin{aligned}
q_a^* = & -\frac{C}{\alpha_H} \left[\frac{f' f''}{\alpha_H^2} u_1^2 + \frac{\bar{C}_p}{Pr} T' + \frac{1}{Sc} \left(\tilde{h}' - \left(\tilde{C}_p + \frac{c_t^2 R}{\mu_1 \mu_2} \right) T' \right. \right. \\
& \left. \left. + c_t R T \mu_3' + (\tilde{h} - h + c_t R T \mu_3) \mu_4' \right) \right] \\
& - \frac{\tilde{\epsilon}_M}{\alpha_H} \left[\frac{f' f''}{\alpha_H^2} u_1^2 + \frac{\bar{C}_p}{Pr_t} T' + \frac{1}{Sc_t} (h' - \bar{C}_p T') \right]
\end{aligned} \tag{3-22}$$

where Pr is the Prandtl number based on the frozen specific heat

$$Pr = \frac{\bar{C}_p u}{\lambda} \tag{3-23}$$

The turbulent contribution to the diffusive energy flux is contained in the last bracketed term, which is left uncombined with the other terms for clarity. The fact that the gross simplifications of the turbulent model are included in the same equation with the rather sophisticated unequal molecular diffusion model is merely a mathematical convenience stimulated by the requirement for calculations in all types of flow situations, including both laminar and turbulent flows. Unequal molecular diffusion and thermal diffusion effects may be important in the laminar sublayer region of a turbulent boundary layer, however.

The normalized molecular diffusive flux of species i is

$$j_i^* = -\frac{C}{\alpha_H \bar{Sc}} [\tilde{Z}_i' + (\tilde{Z}_i - \tilde{K}_i) \mu_4'] \tag{3-24}$$

where \bar{Sc} is a system property defined by

$$\bar{Sc} = \frac{\mu_1 \mu_2}{\rho D \mu_2} \tag{3-25}$$

The \bar{Sc} is a Schmidt number based on the self-diffusion coefficient for a fictitious species representative of the system as a whole. The normalized molecular diffusive flux of the k^{th} "elemental" species is

$$j_k^* = -\frac{C}{\alpha_H \bar{Sc}} [\tilde{Z}_k' + (\tilde{Z}_k - \tilde{K}_k) \mu_4'] \tag{3-26}$$

When certain groupings of parameters are constant so that the flow similarity assumption is valid, the terms on the right-hand side of the conservation equations (Equations (3-9), (3-17), and (3-20)) vanish, in which case the conservation equations become ordinary differential equations. It should be emphasized that the equations as presented herein are equivalent to the corresponding boundary-layer equations presented in Section 2.1. That is, no similarity assumptions have been made in their development.

3.2 INTEGRAL STRIP EQUATIONS WITH SPLINED INTERPOLATION FUNCTIONS

Consider the boundary layer in the region of a given streamwise station s as being divided into $N-1$ strips connecting N nodal points. These nodal points are designated by η_i where $i = 1$ at the wall and N at the edge of the boundary layer. Consider a function $p(\eta)$ which with all its derivatives is continuous in the neighborhood of the point $\eta = \eta_i$. Then, for any value of η in this neighborhood, $p(\eta)$ may be expressed in a Taylor series expansion as

$$p = p_i + p'_i \delta\eta + p''_i \frac{(\delta\eta)^2}{2} + p'''_i \frac{(\delta\eta)^3}{6} + p''''_i \frac{(\delta\eta)^4}{24} + \dots \quad (3-27)$$

where

$$\delta\eta = \eta - \eta_i$$

Conventional finite difference schemes, in effect, typically truncate the Taylor series after the first term and use the resulting expression to relate p' to p , etc., that is

$$p'_i = \frac{p - p_i}{\delta\eta} \quad (3-28)$$

Round-off error is then of order $(\delta\eta)^2$ and many nodes must be chosen to bring this value down to acceptable limits. One can achieve a reduction in the number of nodes for a given accuracy by employing a quadratic or cubic relation representing the function p over the interval of interest. This can be achieved by truncating the Taylor series after the third or fourth term. The cubic approximation will be used for the remainder of this discussion. The p_i can be considered to represent any of f_i , f'_i , f''_i , f'''_i , H_{Ti} , H'_{Ti} , H''_{Ti} , \tilde{k}_{ki} , \tilde{k}'_{ki} , or \tilde{k}''_{ki} . Since the highest derivatives of the dependent variables which appear in the boundary layer equations are f'''_i , H''_{Ti} , and \tilde{k}''_{ki} , it is reasonable to truncate the series at the next highest derivative and to consider that derivative as being constant between η_i and η_{i+1} , that is,

$$f_{i+1}''' = \frac{f_{i+1}''' - f_i'''}{\delta\eta}$$

$$H_{T,i+1}'' = \frac{H_{T,i+1}'' - H_{T,i}''}{\delta\eta} \quad (3-29)$$

$$\tilde{K}_{k,i+1}'' = \frac{\tilde{K}_{k,i+1}'' - \tilde{K}_{k,i}''}{\delta\eta}$$

Thus, rather than using finite difference approximations similar to Equation (3-28) which are substituted directly into the governing differential equations, a set of linear relations between the dependent variables and their derivatives is obtained and is solved simultaneously with the governing differential equations. These linear relations are of the form

$$-f_{i+1} + f_i + f_i' \delta\eta + f_i'' \frac{(\delta\eta)^2}{2} + f_i''' \frac{(\delta\eta)^3}{8} + f_{i+1}''' \frac{(\delta\eta)^3}{24} = 0 \quad (3-30)$$

$$-p_{i+1} + p_i + p_i' \delta\eta + p_i'' \frac{(\delta\eta)^2}{3} + p_{i+1}'' \frac{(\delta\eta)^2}{6} = 0 \quad (3-31)$$

$$-p_{i+1}' + p_i' + p_i'' \frac{\delta\eta}{2} + p_{i+1}'' \frac{\delta\eta}{2} = 0 \quad (3-32)$$

where in Equations (3-31) and (3-32) the p_i represents f_i' , $H_{T,i}$, and each of the K sets of $\tilde{K}_{k,i}$.

Notice that f' has been taken to be a cubic over each strip, rather than the stream function, f , since it was desired to represent velocity ($u = u_1 f' / \alpha_H$) with the cubic. Equations (3-30) through (3-32) above, when written for each adjacent pair of nodes, give $(3 + 2K)(N - 1)$ simultaneous algebraic equations for the $N(4 + 3K) + 1$ unknowns, f_i , f_i' , f_i'' , f_i''' , α_H , $H_{T,i}$, $H_{T,i}'$, $H_{T,i}''$, $\tilde{K}_{k,i}$, $\tilde{K}_{k,i}'$, $\tilde{K}_{k,i}''$ at each stream-wise station, where K is the number of elemental species.* The Taylor series equations are written for only $K-1$ species since the overall mass balance equation supplies the remaining elemental concentration. Additional relations must come from the governing differential equations and the boundary conditions. It is important to note that the f , f' , etc., are treated as individual variables related by algebraic equations. It is also important to note that the coefficients in Equations

* The mixing length is not included in this variables count since mixing length (as well as ϵ_M in the wake region) is treated as a state property.

(3-30) through (3-32) are functions of $\delta\eta$ only; therefore, this portion of the resulting matrix need be inverted only once for a given problem.

The conservation Equations (3-9), (3-17), and (3-20) contain streamwise derivative of "nonsimilar" terms ($d/d \ln \xi$). In the present solution technique, two or three point finite difference formulas are considered sufficient to express these derivatives, since gradients in this direction are not severe. The following relations are used:

$$2 \left[\frac{d(\quad)}{d(\ln \xi)} \right]_{\ell} = d_0(\quad)_{\ell} + d_1(\quad)_{\ell-1} + d_2(\quad)_{\ell-2} \quad (3-33)$$

where $(\quad)_{\ell-1}$ refers to the previous streamwise station,

$$d_0 = \frac{2}{\ell^{\Delta_{\ell-1}}}, \quad d_1 = -\frac{2}{\ell^{\Delta_{\ell-1}}}, \quad d_2 = 0 \quad (3-34)$$

for two-point difference and

$$d_0 = 2 \frac{\ell^{\Delta_{\ell-1}} + \ell^{\Delta_{\ell-2}}}{\ell^{\Delta_{\ell-1}} \ell^{\Delta_{\ell-2}}}, \quad d_1 = -2 \frac{\ell^{\Delta_{\ell-2}}}{\ell^{\Delta_{\ell-1}} \ell^{\Delta_{\ell-2}}}, \quad d_2 = 2 \frac{\ell^{\Delta_{\ell-1}}}{\ell^{\Delta_{\ell-2}} \ell^{\Delta_{\ell-2}}} \quad (3-35)$$

for three-point difference where typically

$$\ell^{\Delta_{\ell-1}} = \ln \xi_{\ell} - \ln \xi_{\ell-1} = \ln (\xi_{\ell}/\xi_{\ell-1}) \quad (3-36)$$

The three-point difference relation is generally used unless a similar solution is desired (in which case $d_0 = d_1 = d_2 = 0$) or unless the point in question is the first point after either (1) a similar solution or (2) a discontinuity (e.g., where the body changes shape abruptly, or where mass injection is suddenly terminated).

The next step in the treatment of the conservation equations is their integration across the boundary layer "strips". The primary reason for this integration is to simplify the η -derivative terms in the energy and species conservation equations, since it is not convenient to express the complex q_a^* and j_k^* terms in derivative form. The solution can actually proceed very nicely without integrating across strips (see Reference 29) without any noticeable change in speed, accuracy, or stability for simplified problems such as incompressible, nonreacting flows. The weighting function for integration between nodes in this integral method is unity.

In the terminology of the general method of integral relations, where integrals are carried from 0 to ∞ in η (Reference 30), a square wave weighting function is used which is unity across the strip in question and zero elsewhere. The equations are then integrated N-1 times with the square wave applied to each strip in succession. Using the momentum equation as an example, the integration from $i-1$ to i results in

$$\begin{aligned}
 & \int_{i-1}^i f f'' d\eta + \left[\frac{t(C + \tilde{\epsilon}_M)}{\alpha_H} f'' \right]_{i-1}^i + \beta_p \alpha_H^2 \int_{i-1}^i \frac{\rho_1}{\rho} d\eta - \beta_v \int_{i-1}^i f'^2 d\eta \\
 &= \int_{i-1}^i f' (d_0 f' + d_1 f'_{\ell-1} + d_2 f'_{\ell-2}) d\eta - \int_{i-1}^i f'^2 [d_0 \ln \alpha_H \\
 &+ d_1 (\ln \alpha_H)_{\ell-1} + d_2 (\ln \alpha_H)_{\ell-2}] d\eta - \int_{i-1}^i f'' (d_0 f + d_1 f_{\ell-1} \\
 &+ d_2 f_{\ell-2}) d\eta
 \end{aligned} \tag{3-37}$$

where Equation (3-33) has also been introduced into Equation (3-9). The Taylor series approximations introduced earlier can also be used to express the integral terms above. As demonstrated in Reference 1, the term $\int_{i-1}^i f' p d\eta$ becomes

$$\int_{i-1}^i f' p d\eta = f'_i X P_1 + f''_i X P_2 + f'''_i X P_3 + f^{(4)}_i X P_4 \tag{3-38}$$

where

$$\begin{aligned}
 X P_1 &= \delta\eta \left(p_i - p'_i \frac{\delta\eta}{2} + p''_i \frac{(\delta\eta)^2}{8} + p'''_i \frac{(\delta\eta)^3}{24} \right) \\
 X P_2 &= -(\delta\eta)^2 \left(\frac{p_i}{2} - p'_i \frac{\delta\eta}{3} + p''_i \frac{11(\delta\eta)^2}{120} + p'''_i \frac{(\delta\eta)^3}{30} \right) \\
 X P_3 &= (\delta\eta)^3 \left(\frac{p_i}{8} - p'_i \frac{11(\delta\eta)}{120} + p''_i \frac{11(\delta\eta)^2}{420} + p'''_i \frac{5(\delta\eta)^3}{504} \right)
 \end{aligned} \tag{3-39}$$

Continued

$$XP_4 = (\delta\eta)^3 \left(\frac{p_i}{24} - p_i' \frac{\delta\eta}{30} + p_i'' \frac{5(\delta\eta)^2}{504} + p_{i-1}'' \frac{(\delta\eta)^2}{252} \right) \quad (3-39)$$

This technique is used to rewrite each of the integral terms in Equation (3-37) that have the form $\int_{i-1}^i f' p \, d\eta$. The remaining integral term in the momentum equation, $\int_{i-1}^i (\rho_1/\rho) \, d\eta$ is evaluated by approximating the function as a cubic over the strip and integrating directly. This yields

$$\int_{i-1}^i \frac{\rho_1}{\rho} \, d\eta = \left(\frac{\rho_1}{\rho} + \frac{\rho_1}{\rho_{i-1}} \right) \frac{\delta\eta}{2} + \left(\frac{\rho_1 \rho_i'}{\rho_i^2} - \frac{\rho_1 \rho_{i-1}'}{\rho_{i-1}^2} \right) \frac{\delta\eta^2}{12} \quad (3-40)$$

The production term* in the species equation is assumed to vary linearly across the strip so that the integral of ϕ_k/ρ is

$$\int_{i-1}^i \frac{\phi_k}{\rho} \, dy = \left[\left(\frac{\phi_k}{\rho} \right)_i + \left(\frac{\phi_k}{\rho} \right)_{i-1} \right] \frac{\delta\eta}{2} \quad (3-41)$$

These approximations are not quite as good as the approximations for f' , H_T and \tilde{K}_k since continuity of derivatives is not guaranteed at the nodal point.

Direct substitution of these approximations for integral terms into the governing equations results in the following forms.

Momentum

$$\begin{aligned} & \left[\frac{t(C + \tilde{\epsilon}_M)}{\alpha_H} f'' + f' \left((1 + d_0)f + d_1 f_{\ell-1} + d_2 f_{\ell-2} \right) \right]_{i-1}^i \\ & + \beta_\rho \alpha_H^2 \left[\left(\frac{\rho_1}{\rho_i} + \frac{\rho_1}{\rho_{i-1}} \right) \frac{\delta\eta}{2} + \left(\frac{\rho_1 \rho_i'}{\rho_i^2} - \frac{\rho_1 \rho_{i-1}'}{\rho_{i-1}^2} \right) \frac{(\delta\eta)^2}{12} \right] \\ & - \left(1 + \beta_V + d_0 - \frac{d_1 \alpha_{H_{\ell-1}} + d_2 \alpha_{H_{\ell-2}}}{\alpha_H} \right) [f_i' XP_1 + f_i'' XP_2 \\ & + f_i''' XP_3 + f_{i-1}''' XP_4]_{p_i=f_i} - 2 [f_i' ZP_1 + f_i'' ZP_2 + f_i''' ZP_3 \\ & + f_{i-1}''' ZP_4]_{p_i=f_i} = 0 \end{aligned} \quad (3-42)$$

*Recall that for equilibrium chemistry this term is identically zero.

Energy

$$\begin{aligned}
 & \left[t(-q_a^* + q_r^*) + H_T ((1 + d_0) f + d_1 f_{\ell-1} + d_2 f_{\ell-2}) \right]_{i-1}^i \\
 & - (1 + 2d_0) [f_i' XP_1 + f_i'' XP_2 + f_i''' XP_3 + f_{i-1}''' XP_4]_{p_i=H_{T_i}} \\
 & - [f_i' ZP_1 + f_i'' ZP_2 + f_i''' ZP_3 + f_{i-1}''' ZP_4]_{p_i=H_{T_i}} \\
 & - [H_{T_i} ZP_1 + H_{T_i}' ZP_2 + H_{T_i}'' ZP_3 + H_{T_{i-1}}'' ZP_4]_{p_i=f_i'} = 0 \quad (3-43)
 \end{aligned}$$

"Elemental" Species

$$\begin{aligned}
 & \left[t \left(\frac{\tilde{\epsilon}_M}{\alpha_H \tilde{S} C_t} \tilde{K}_k' - j_k^* \right) + \tilde{K}_k ((1 + d_0) f + d_1 f_{\ell-1} + d_2 f_{\ell-2}) \right]_{i-1}^i + \frac{\alpha_H \rho e^\mu}{\alpha^*{}^2} \left[\left(\frac{\phi_k}{\rho} \right)_i \right. \\
 & \left. + \left(\frac{\phi_k}{\rho} \right)_{i-1} \right] \frac{\delta \eta}{2} - (1 + 2d_0) [f_i' XP_1 + f_i'' XP_2 + f_i''' XP_3 \\
 & + f_{i-1}''' XP_4]_{p_i=\tilde{K}_{k_i}} - [f_i' ZP_1 + f_i'' ZP_2 + f_i''' ZP_3 + f_{i-1}''' ZP_4]_{p_i=\tilde{K}_{k_i}} \\
 & - [\tilde{K}_{k_i}' ZP_1 + \tilde{K}_{k_i}'' ZP_2 + \tilde{K}_{k_i}''' ZP_3 + \tilde{K}_{i-1}''' ZP_4]_{p_i=f_i'} = 0 \quad (3-44)
 \end{aligned}$$

The following definitions are necessary:

$$\begin{aligned}
 ZP_1 &= \delta \eta \left(YP_1 - YP_2 \frac{\delta \eta}{2} + YP_3 \frac{(\delta \eta)^2}{8} + YP_4 \frac{(\delta \eta)^2}{24} \right) \\
 ZP_2 &= -(\delta \eta)^2 \left(\frac{YP_1}{2} - YP_2 \frac{\delta \eta}{3} + YP_3 \frac{11(\delta \eta)^2}{120} + YP_4 \frac{(\delta \eta)^2}{30} \right) \\
 ZP_3 &= (\delta \eta)^3 \left(\frac{YP_1}{8} - YP_2 \frac{11\delta \eta}{120} + YP_3 \frac{11(\delta \eta)^2}{420} + YP_4 \frac{5(\delta \eta)^2}{504} \right) \\
 ZP_4 &= (\delta \eta)^3 \left(\frac{YP_1}{24} - YP_2 \frac{\delta \eta}{30} + YP_3 \frac{5(\delta \eta)^2}{504} + YP_4 \frac{(\delta \eta)^2}{252} \right)
 \end{aligned} \quad (3-45)$$

with

$$\begin{aligned}
 YP_1 &= d_1 p_{\ell-1,i} + d_2 p_{\ell-2,i} \\
 YP_2 &= d_1 p'_{\ell-1,i} + d_2 p'_{\ell-2,i} \\
 YP_3 &= d_1 p''_{\ell-1,i} + d_2 p''_{\ell-2,i} \\
 YP_4 &= d_1 p''_{\ell-1,i-1} + d_2 p''_{\ell-2,i-1}
 \end{aligned}
 \tag{3-46}$$

and p_i is defined adjacent to the brackets in each term that uses these definitions.

The conservation equations provide $(K+1)(N-1)$ more equations for the $N(3K+4)+1$ unknowns. The remaining equations needed to close the problem (number of equations = number of unknowns) come from the boundary conditions, Equations (2-81) and (2-82) and one of Equations (2-84), (2-85), or (2-89). These equations provide $4+3K$ relations.

3.3 SOLUTION OF THE MIXING LENGTH EQUATION

The turbulent mixing length is treated in the same way as the thermodynamic and transport properties, i.e., from an assumed boundary layer solution the mixing length is calculated at each node and used in the next iteration. This is a simple matter for the Cebeci and Bushnell models since the mixing length expression in both is an algebraic formula. However, in the Kendall model a differential equation must be solved. Accordingly, some discussion of this procedure follows.

The transformed differential equation for the Kendall model mixing length is given by

$$\frac{d\tilde{\ell}}{d\eta} = \frac{\alpha_H \rho_1 \delta \sqrt{\tau/\rho}}{y_a + \mu} (k\alpha_H \eta - \tilde{\ell})
 \tag{3-47}$$

where τ/ρ is given by

$$\frac{\tau}{\rho} = \frac{u_1^2}{\alpha_H} \frac{\rho_1}{\rho} \left[\frac{C_W}{\alpha_H} \frac{f''_W}{Re_\delta} + \frac{\rho_W v_W}{\rho_1 u_1} f' \right]
 \tag{3-48}$$

and the definitions of Equations (3-14) have been used. Defining $P(\eta)$ by:

$$P(\eta) = \frac{\alpha_H \rho_1 \delta \sqrt{\tau/\rho}}{y_a \mu} \quad (3-49)$$

results in

$$\frac{d\tilde{\ell}}{d\eta} = (k\alpha_H \eta - \tilde{\ell}) P \quad (3-50)$$

The solution to this equation is

$$\tilde{\ell} = k\alpha_H \left[\eta - \frac{\int_0^\eta e^{\int_0^{\eta'} P d\eta'} d\eta'}{\int_0^\eta e^{\int_0^{\eta'} P d\eta'} d\eta'} \right] \quad (3-51)$$

The remaining problem is to evaluate the integral terms. Defining

$$L(\eta) = \frac{\int_0^\eta e^{\int_0^{\eta'} P d\eta''} d\eta'}{\int_0^\eta e^{\int_0^{\eta'} P d\eta'} d\eta'} \quad (3-52)$$

yields

$$\tilde{\ell} = k\alpha_H (\eta - L) \quad (3-53)$$

Reference 2 presents a complete description of the technique used to evaluate $L(\eta)$. In essence, $P(\eta)$ is assumed to vary linearly over the interval η_{i-1} to η_i , and the integrals are expressed in a more tractable form. The final expression is

$$L_i = BL_{i-1} + A \left\{ D_w \left(\frac{AP_i}{2} \right) - BD_w \left(\frac{AP_{i-1}}{2} \right) \right\} \quad (3-54)$$

where

$$A = \left[\frac{2\Delta\eta_i}{P_i - P_{i-1}} \right]^{1/2} \quad (3-55)$$

$$B = e^{-\Delta\eta_i \left[\frac{P_i - P_{i-1}}{2} \right]} \quad (3-56)$$

$$\Delta\eta_i = \eta_i - \eta_{i-1} \quad (3-57)$$

$$D_w(\) = e^{-(\)^2} \int_0^{(\)} e^{+y^2} dy \quad (3-58)$$

The Dawson Integral, $D_w(\)$, can be evaluated from tables (Reference 31) or by a series method. A series evaluation method is used in the present analysis. Thus, combining Equations (3-53) and (3-54), an explicit recursion formula for mixing length at each node is obtained. This mixing length is a function of local shear, viscosity, and density through the variation of $P(\)$, and is re-evaluated at each node on each iteration during the course of a solution.

3.4 NEWTON-RAPHSON ITERATION FOR A SOLUTION

A complete description of the Newton-Raphson iteration procedure as applied to the laminar equations of motion was given in Reference 1. Since the procedure is basically unchanged with the addition of turbulent transport it will be reviewed only briefly here, with emphasis on the recent additions.

To illustrate the Newton-Raphson method, consider two simultaneous nonlinear algebraic equations in two variables, x and y .

$$F(x,y) = 0 \quad G(x,y) = 0 \quad (3-59)$$

the solution for which is given by $x = \bar{x}$, $y = \bar{y}$. Define x_m and y_m as the values of x and y for the m^{th} iteration. The desired solution $F(\bar{x}, \bar{y})$ can be expressed in a Taylor series expansion:

$$\begin{aligned}
0 &= F(\bar{x}, \bar{y}) = F(x_m, y_m) + (\bar{x} - x_m) \frac{\partial F(x_m, y_m)}{\partial x} \\
&\quad + (\bar{y} - y_m) \frac{\partial F(x_m, y_m)}{\partial y} + \dots \\
0 &= G(\bar{x}, \bar{y}) = G(x_m, y_m) + (\bar{x} - x_m) \frac{\partial G(x_m, y_m)}{\partial x} \\
&\quad + (\bar{y} - y_m) \frac{\partial G(x_m, y_m)}{\partial y} + \dots
\end{aligned} \tag{3-60}$$

The Newton-Raphson method consists of replacing (x, y) by (x_{m+1}, y_{m+1}) on the right-hand side of these expressions and neglecting terms of higher order than those shown in Equation (3-60). This yields the set of simultaneous equations

$$\begin{aligned}
\Delta x_m \frac{\partial F(x_m, y_m)}{\partial x} + \Delta y_m \frac{\partial F(x_m, y_m)}{\partial y} &= -F(x_m, y_m) \\
\Delta x_m \frac{\partial G(x_m, y_m)}{\partial x} + \Delta y_m \frac{\partial G(x_m, y_m)}{\partial y} &= -G(x_m, y_m)
\end{aligned} \tag{3.61}$$

or in matrix form

$$\begin{bmatrix} \frac{\partial F(x_m, y_m)}{\partial x} & \frac{\partial F(x_m, y_m)}{\partial y} \\ \frac{\partial G(x_m, y_m)}{\partial x} & \frac{\partial G(x_m, y_m)}{\partial y} \end{bmatrix} \begin{bmatrix} \Delta x_m \\ \Delta y_m \end{bmatrix} = \begin{bmatrix} -F(x_m, y_m) \\ -G(x_m, y_m) \end{bmatrix} \tag{3-61a}$$

where

$$\Delta x_m \equiv x_{m+1} - x_m \quad \Delta y_m \equiv y_{m+1} - y_m$$

The Δx_m and Δy_m are the corrections to be added to x_m and y_m , respectively, to yield the values of the dependent variables for the $m+1^{\text{th}}$ iteration. Here $F(x_m, y_m)$ and $G(x_m, y_m)$ are values of the original functions $F(x, y)$ and $G(x, y)$ evaluated for $x = x_m$ and $y = y_m$. As the corrections approach zero, the $F(x_m, y_m)$ and $G(x_m, y_m)$ approach

zero. Hence, it is appropriate to look upon the $F(x_m, y_m)$ and $G(x_m, y_m)$ as errors associated with the original equation (Equation (3-59)). It is apparent that this procedure can be extended to an arbitrary number of functions and a corresponding number of primary variables.

In the following discussion the matrix of partial derivatives is referred to as the matrix of correction coefficients. The number of equations and unknowns is greatly increased; however, the basic procedure is the same. In matrix notation

$$\bar{A} \cdot (\bar{x}_{m+1} - \bar{x}_m) = \bar{A} \cdot (\Delta \bar{x}_m) = -F(\bar{x}_m) \quad (3-62)$$

where \bar{A} is the matrix of partial derivatives, \bar{x} is a column vector containing all the primary variables (f_i , etc.) and \bar{F} is the set of governing equations. The procedure to arrive at a solution $\bar{F}(\bar{x}) = \bar{0}$ is as follows:

- Start with the m^{th} guess for a solution, \bar{x}_m
- Compute $-F(\bar{x}_m)$ and compare to $\bar{0}$ (the zero vector) if close enough, accept \bar{x}_m as the solution
- Compute \bar{A} corresponding to \bar{x}_m
- Invert \bar{A} and calculate \bar{x}_{m+1} from

$$\bar{x}_{m+1} = (\Delta \bar{x}_m) + \bar{x}_m = -\bar{A}^{-1} \bar{F}(\bar{x}_m) + \bar{x}_m \quad (3-63)$$

The mechanics of how this is done are described in Section 3.6.

3.5 THE MATRIX OF CORRECTION COEFFICIENTS

For the purpose of the present analysis, it has been found most convenient to consider the primary variables as f_i, f_i', f_i'', f_i''' , $H_{T_i}, H_{T_i}', H_{T_i}'', \tilde{K}_{k_i}, \tilde{K}_{k_i}', \tilde{K}_{k_i}''$, and α_H . This amounts to $N(3K + 4) + 1$ unknowns where N is the number of nodes and K is the number of elemental species to be considered in the boundary layer. Re-counting the number of equations, we have

	Equation Number	No. of Equations
Taylor series expansions	(3-30) - (3-32)	$(3 + 2K)(N - 1)$
Boundary layer equations	(3-42) - (3-44)	$(N - 1)(K + 1)$
Boundary conditions	(2-77), (2-78), (2-80) or equivalent	$3K + 4$
α_H definition	(3-3)	1
Total		$N(3K + 4) + 1$

Other secondary variables such as ϵ , ρ , T , etc., are expressed in terms of those listed above. The corrections in these secondary variables are therefore found in terms of the corrections to the primary variables.

The use of the Newton-Raphson technique for the current set of equations requires the evaluation of the partial derivatives of each equation with respect to each variable. The Taylor series expansions are linear with respect to the primary variables as are several of the boundary conditions. The boundary layer equations and the remainder of the boundary conditions are nonlinear. The α_H constraint is linear but it must be considered together with the nonlinear equations in order to avoid a singular matrix. The recurrence formulas representing the linear equations will be presented first, after which recurrence formulas appropriate to the nonlinear equations will be developed.

Partial differentiation of the Taylor series expansions with respect to the primary dependent variables in accordance with Equations (3-61) yields for the m^{th} iteration

$$(-1)\Delta f_{i+1} + (1)\Delta f_i + (\delta\eta)\Delta f'_i + \left(\frac{\delta\eta^2}{2}\right)\Delta f''_i + \left(\frac{\delta\eta^3}{8}\right)\Delta f'''_i + \left(\frac{\delta\eta^3}{24}\right)\Delta f''''_{i+1} = - \text{ERROR} \quad (3-64)$$

$$(-1)\Delta p_{i+1} + (1)\Delta p_i + (\delta\eta)\Delta p'_i + \left(\frac{\delta\eta^2}{3}\right)\Delta p''_i + \left(\frac{\delta\eta^2}{6}\right)\Delta p'''_{i+1} = - \text{ERROR} \quad (3-65)$$

$$(-1)\Delta p'_{i+1} + (1)\Delta p'_i + \left(\frac{\delta\eta}{2}\right)\Delta p''_i + \left(\frac{\delta\eta}{2}\right)\Delta p'''_{i+1} = - \text{ERROR} \quad (3-66)$$

where as before p_i represents f'_i , H_{T_i} , and \tilde{K}_{k_i} . Here Δf_{i+1} , Δf_i , $\Delta f'_i$, and so on represent the respective corrections for f_{i+1} , f_i , f'_i , and so on, the numbers in parentheses represent the partial derivatives of the Taylor series expressions (Equations (3-30) through (3-32)) with respect to the primary variables; and the ERRORS are obtained by evaluating the left-hand sides of the appropriate Equations (3-30) through (3-32) for the values of the variables obtained during the m^{th} iteration.

Similarly, the recurrence formulas for the linear boundary conditions (Equations (2-77), (2-78), (2-80), etc.) are:

$$\Delta f'_w = - \text{ERROR} = - (f'_w)_m \quad (3-67)$$

$$\Delta H_{T_{\text{edge}}} = - \text{ERROR} = - [H_{T_{\text{edge}}} - H_{T_{\text{edge}}} |_{\text{actual}}]_m \quad (3-68)$$

$$\Delta H_{T_{edge}}^i = - \text{ERROR} = - (H_{T_{edge}}^i)_m \quad (3-69)$$

$$\Delta \tilde{K}_{k_{edge}} = - \text{ERROR} = - [\tilde{K}_{k_{edge}} - \tilde{K}_{k_{edge}}|_{\text{actual}}]_m \quad (3-70)$$

$$\Delta \tilde{K}_{k_{edge}} = - \text{ERROR} = - (\tilde{K}_{k_{edge}})_m \quad (3-71)$$

The recurrence formulas for the nonlinear boundary-layer equations are given by:

Momentum

$$\begin{aligned} & \left[\frac{t(C + \tilde{\epsilon}_M)f''}{\alpha_H} \left(\frac{\Delta f''}{f''} + \frac{\Delta C}{C} + \frac{\Delta \tilde{\epsilon}_M}{\tilde{\epsilon}_M} - \frac{\Delta \alpha_H}{\alpha_H} + \frac{\Delta t}{t} \right) + [(1 + d_0)f + d_1 f_{\ell-1} + d_2 f_{\ell-2}] \Delta f' \right. \\ & \quad + f'(1 + d_0) \Delta f \Big]_{i-1}^i - \beta_\rho \alpha_H^2 \frac{\rho_1}{\rho_i^2} \frac{\delta \eta}{2} \left\{ \left(1 + \frac{\delta \eta}{3} \frac{\rho_i'}{\rho_i} \right) \Delta \rho_i \right. \\ & \quad \left. - \frac{\delta \eta}{6} \Delta \rho_i' + \left(\frac{\rho_i}{\rho_{i-1}} \right)^2 \left[\left(1 - \frac{\delta \eta}{3} \frac{\rho_{i-1}'}{\rho_{i-1}} \right) \Delta \rho_{i-1} + \frac{\delta \eta}{6} \Delta \rho_{i-1}' \right] \right\} \\ & \quad + \beta_\rho \alpha_H \delta \eta \frac{\rho_1}{\rho_i} \left[1 + \frac{\rho_i}{\rho_{i-1}} + \frac{\delta \eta}{6} \left(\frac{\rho_i'}{\rho_i} - \frac{\rho_i}{\rho_{i-1}} \frac{\rho_{i-1}'}{\rho_{i-1}} \right) \right] \Delta \alpha_H \\ & \quad - \left[1 + \beta_v + d_0 - \left(\frac{d_1 \alpha_{H_{\ell-1}} + d_2 \alpha_{H_{\ell-2}}}{\alpha_H} \right) \right] [f_i' \Delta X P_1 \\ & \quad + f_i'' \Delta X P_2 + f_i''' \Delta X P_3 + f_{i-1}''' \Delta X P_4 + X P_1 \Delta f_i' + X P_2 \Delta f_i'' \\ & \quad + X P_3 \Delta f_i''' + X P_4 \Delta f_{i-1}''']_{p_i=f_i'} - \left(\frac{d_1 \alpha_{H_{\ell-1}} + d_2 \alpha_{H_{\ell-2}}}{\alpha_H^2} \right) [f_i' X P_1 \\ & \quad + f_i' X P_2 + f_i''' X P_3 + f_{i-1}''' X P_4]_{p_i=f_i'} \Delta \alpha_H - 2 [Z P_1 \Delta f_i' + Z P_2 \Delta f_i'' \\ & \quad + Z P_3 \Delta f_i''' + Z P_4 \Delta f_{i-1}''']_{p_i=f_i'} = - \text{ERROR} \end{aligned} \quad (3-72)$$

where the ERROR is given by the left-hand side of Equation (3-42) evaluated for m^{th} iteration.

Energy

$$\begin{aligned}
 & [t(-\Delta q_a^* + \Delta q_r^*) + (-q_a^* + q_r^*)\Delta t + ((1 + d_0) f + d_1 f_{\ell-1} + d_2 f_{\ell-2}) \Delta H_T \\
 & + H_T (1 + d_0) \Delta f]_{i-1}^i - (1 + 2d_0) [f_i' \Delta XP_1 + f_i'' \Delta XP_2 \\
 & + f_i''' \Delta XP_3 + f_{i-1}''' \Delta XP_4 + XP_1 \Delta f_i' + XP_2 \Delta f_i'' + XP_3 \Delta f_i''' \\
 & + XP_4 \Delta f_{i-1}''']_{p_i=H_{T_i}} - [ZP_1 \Delta f_i' + ZP_2 \Delta f_i'' + ZP_3 \Delta f_i''' \\
 & + ZP_4 \Delta f_{i-1}''']_{p_i=H_{T_i}} - [ZP_1 \Delta H_{T_i}' + ZP_2 \Delta H_{T_i}'' + ZP_3 \Delta H_{T_i}''' \\
 & + ZP_4 \Delta H_{T_{i-1}}''']_{p_i=f_i'} = - \text{ERROR}
 \end{aligned} \tag{3-73}$$

where the ERROR is given by the left-hand side of Equation (3-43) for the m^{th} iteration and Δq_a^* is given by

$$\begin{aligned}
 \Delta q_a^* = & - \frac{(C + \tilde{\epsilon}_M) f' f'' u_1^2}{\alpha_H^3} \left(\frac{\Delta C}{C} + \frac{\Delta \tilde{\epsilon}_M}{\tilde{\epsilon}_M} + \frac{\Delta f'}{f'} + \frac{\Delta f''}{f''} - 3 \frac{\Delta \alpha_H}{\alpha_H} \right) + \frac{CC_p T'}{\alpha_H Pr} \left(\frac{\Delta C}{C} \right. \\
 & + \frac{\Delta \bar{C}_p}{C} + \frac{\Delta T'}{T'} - \frac{\Delta \alpha_H}{\alpha_H} - \frac{\Delta Pr}{Pr} \left. \right) + \frac{\tilde{\epsilon}_M \bar{C}_p T'}{\alpha_H Pr_t} \left(\frac{\Delta \tilde{\epsilon}_M}{\tilde{\epsilon}_M} + \frac{\Delta \bar{C}_p}{\bar{C}_p} + \frac{\Delta T'}{T'} - \frac{\Delta \alpha_H}{\alpha_H} \right) \\
 & + \frac{C}{\alpha_H Sc} \left[\bar{h}' - \left(\bar{C}_p + \frac{c_t^2 R}{\mu_1 \mu_2} \right) T' + c_t RT \mu_3' + (\bar{h} - h + c_t RT \mu_3) \mu_4' \right] \left[\frac{\Delta C}{C} \right. \\
 & - \frac{\Delta \alpha_H}{\alpha_H} - \frac{\Delta Sc}{Sc} \left. \right] + \frac{\tilde{\epsilon}_M}{\alpha_H Sc_t} (h' - \bar{C}_p T') \left[\frac{\Delta \tilde{\epsilon}_M}{\tilde{\epsilon}_M} - \frac{\Delta \alpha_H}{\alpha_H} \right] + \frac{C}{\alpha_H Sc} \left[\Delta \bar{h}' \right.
 \end{aligned}$$

Continued

$$\begin{aligned}
& - \left(\tilde{C}_p + \frac{c_t^2 R}{\mu_1 \mu_2} \right) \Delta T' - T' \Delta \tilde{C}_p + \frac{c_t^2 R T'}{(\mu_1 \mu_2)^2} \Delta(\mu_1 \mu_2) + c_t R T \mu_3' \left(\frac{\Delta T}{T} \right. \\
& + \frac{\Delta \mu_3'}{\mu_3'} \left. \right) + (\tilde{h} - h + c_t R T \mu_3) \Delta \mu_4' + \mu_4' \left(\Delta \tilde{h} - \Delta h + c_t R T \mu_3 \left(\frac{\Delta \mu_3}{\mu_3} \right. \right. \\
& \left. \left. + \frac{\Delta T}{T} \right) \right) + \frac{\tilde{\epsilon}_M}{\alpha_H \bar{S} c_t} [\Delta h' - \bar{C}_p \Delta T' - T' \Delta \bar{C}_p] \quad (3-74)
\end{aligned}$$

"Elemental" Species

$$\begin{aligned}
& \left[-t \Delta j_k^* - j_k^* \Delta t + \frac{\tilde{\epsilon}_M \tilde{K}_k' t}{\alpha_H \bar{S} c_t} \left(\frac{\Delta \tilde{K}_k'}{\tilde{K}_k'} - \frac{\Delta \alpha_H}{\alpha_H} + \frac{\Delta \tilde{\epsilon}_M}{\tilde{\epsilon}_M} + \frac{\Delta t}{t} \right) + ((1 + d_0) f + d_1 f_{l-1} \right. \\
& + d_2 f_{l-2}) \Delta \tilde{K}_k + \tilde{K}_k (1 + d_0) \Delta f \Big]_{i-1}^i + \frac{\rho_e \mu_e}{\alpha^{*2}} \left\{ \alpha_H \frac{\delta \eta}{2} \left[\Delta \left(\frac{\phi_k}{\rho} \right)_i + \Delta \left(\frac{\phi_k}{\rho} \right)_{i-1} \right. \right. \\
& \left. \left. + \frac{\delta \eta}{2} \left(\frac{\phi_k}{\rho} \right)_i + \left(\frac{\phi_k}{\rho} \right)_{i-1} \right] \Delta \alpha_H \right\} - (1 + 2d_0) [f_i' \Delta X P_1 + f_i'' \Delta X P_2 + f_i''' \Delta X P_3 \\
& + f_{i-1}''' \Delta X P_4 + X P_1 \Delta f_i' + X P_2 \Delta f_i'' + X P_3 \Delta f_i''' + X P_4 \Delta f_{i-1}''']_{p_i = \tilde{K}_{k_i}} \\
& - [Z P_1 \Delta f_i' + Z P_2 \Delta f_i'' + Z P_3 \Delta f_i''' + Z P_4 \Delta f_{i-1}''']_{p_i = \tilde{K}_{k_i}} - [Z P_1 \Delta \tilde{K}_{k_i} \\
& + Z P_2 \Delta K_{k_i}' + Z P_3 \Delta \tilde{K}_{k_i}'' + Z P_4 \Delta \tilde{K}_{k_i}''']_{p_i = f_i'} = - \text{ERROR} \quad (3-75)
\end{aligned}$$

where the ERROR is given by the left-hand side of Equation (3-44) evaluated for the m^{th} iteration and Δj_k^* is given by

$$\begin{aligned}
\Delta j_k^* = & - \frac{C}{\alpha_H \bar{S} c} \left[(\tilde{Z}_k' + (\tilde{Z}_k - \tilde{K}_k) \mu_4') \left(\frac{\Delta C}{C} - \frac{\Delta \alpha_H}{\alpha_H} - \frac{\Delta \bar{S} c}{\bar{S} c} \right) \right. \\
& \left. + \Delta \tilde{Z}_k' + (\tilde{Z}_k - \tilde{K}_k) \Delta \mu_4' + \mu_4' (\Delta \tilde{Z}_k - \Delta \tilde{K}_k) \right] \quad (3-76)
\end{aligned}$$

Equations (3-72), (3-73), and (3-75) are reduced to linear equations in terms of the corrections on the primary variables ($\Delta f'_i$, $\Delta f'_j$, and so on) by noting that the variables C , ρ , \bar{C}_p , T , Pr , \bar{Sc} , \tilde{h} , \tilde{C}_p , $\mu_1\mu_2$, μ_3 , μ_4 , q_r , \tilde{Z}_k , ϵ_M , and ϕ_k evaluated at any point in the boundary layer can be considered as functions of static enthalpy, static pressure, and elemental composition. With the pressure assumed constant across the boundary layer, it follows that all of the corrections on unprimed variables with the exception of Δq_r can be expressed as

$$\Delta()_i = \sum_k \frac{\partial()_i}{\partial \tilde{K}_{k_i}} \Delta \tilde{K}_{k_i} + \frac{\partial()_i}{\partial h_i} \Delta h_i \quad (3-77)$$

where from Equations (2-14) and (3-5)

$$h_i = H_{T_i} - \frac{u_i^2}{2} \frac{f_i'^2}{\alpha_H^2} \quad (3-78)$$

so that

$$\Delta h_i = \Delta H_{T_i} - \frac{u_i^2 f_i'^2}{\alpha_H^2} \left(\frac{\Delta f_i'}{f_i'} - \frac{\Delta \alpha_H}{\alpha_H} \right) \quad (3-79)$$

The Δq_{r_i} is more complicated in that it depends upon the $\Delta \tilde{K}_{k_j}$ and Δh_j at all nodal points j .

The η -derivatives of these variables (i.e., the primed quantities) can likewise be expressed in terms of corrections on the primary variables as follows

$$\begin{aligned} \Delta()'_i = & \sum_k \tilde{K}_{k_i} \left(\sum_{kk} \frac{\partial^2()_i}{\partial \tilde{K}_{k_i} \partial \tilde{K}_{kk_i}} \Delta \tilde{K}_{kk_i} + \frac{\partial^2()_i}{\partial \tilde{K}_{k_i} \partial h_i} \Delta h_i \right) \\ & + h'_i \left(\sum_k \frac{\partial^2()_i}{\partial h_i \partial \tilde{K}_{k_i}} \Delta \tilde{K}_{k_i} + \frac{\partial^2()_i}{\partial h_i^2} \Delta h_i \right) \\ & + \sum_k \frac{\partial()_i}{\partial \tilde{K}_{k_i}} \Delta \tilde{K}'_{k_i} + \frac{\partial()_i}{\partial h_i} \Delta h'_i \end{aligned} \quad (3-80)$$

where

$$h_i' = H_{T_i}' - \frac{u_1^2 f_i' f_i''}{\alpha_H^2} \quad (3-81)$$

so that

$$\Delta h_i' = \Delta H_{T_i}' - \frac{u_1^2 f_i' f_i''}{\alpha_H^2} \left(\frac{\Delta f_i'}{f_i'} + \frac{\Delta f_i''}{f_i''} - 2 \frac{\Delta \alpha_H}{\alpha_H} \right) \quad (3-82)$$

Use is also made of the following definitions which are obtained by differentiating Equations (3-39):

$$\begin{aligned} \Delta XP_1 &= \delta \eta \left(\Delta p_i - \frac{\delta \eta}{2} \Delta p_i' + \frac{\delta \eta^2}{8} \Delta p_i'' + \frac{\delta \eta^2}{24} \Delta p_{i-1}'' \right) \\ \Delta XP_2 &= -\delta \eta^2 \left(\frac{\Delta p_i}{2} - \frac{\delta \eta}{3} \Delta p_i' + \frac{11 \delta \eta^2}{120} \Delta p_i'' + \frac{\delta \eta^2}{30} \Delta p_{i-1}'' \right) \\ \Delta XP_3 &= \delta \eta^3 \left(\frac{\Delta p_i}{8} - \frac{11 \delta \eta}{120} \Delta p_i' + \frac{11 \delta \eta^2}{420} \Delta p_i'' + \frac{5 \delta \eta^2}{504} \Delta p_{i-1}'' \right) \\ \Delta XP_4 &= \delta \eta^3 \left(\frac{\Delta p_i}{24} - \frac{\delta \eta}{30} \Delta p_i' + \frac{5 \delta \eta^2}{252} \Delta p_i'' + \frac{\delta \eta^2}{252} \Delta p_{i-1}'' \right) \end{aligned} \quad (3-83)$$

The $\Delta ZP_1 = \Delta ZP_2 = \Delta ZP_3 = \Delta ZP_4 = 0$ since ZP_1, ZP_2, ZP_3 , and ZP_4 can be computed before the iteration commences.

In order to complete the set of equations, it is necessary to develop the recurrence formulas for the α_H constraint and for the nonlinear boundary conditions. The α_H constraint (Equation (3-3)) yields

$$\Delta f_{\eta_c}' - c \Delta f_{\eta_e}' = - \text{ERROR} = - (f_{\eta_c}' - c f_{\eta_e}')_m \quad (3-84)$$

Once the correction coefficients (partial derivatives with respect to each primary variable) for each equation at each nodal point are found, they are arranged in matrix form for further manipulation. The order of the primary variables and the order of the equations is of some importance in the matrix formulation. It is most convenient to divide the variables into "linear" (Symbol L) and "nonlinear" (Symbol NL) sets, namely:

$$\begin{bmatrix} \text{AL} & \text{BL} \\ \text{ANL} & \text{BNL} \end{bmatrix} \begin{bmatrix} \Delta \text{VL} \\ \Delta \text{VNL} \end{bmatrix} = - \begin{bmatrix} \text{EL} \\ \text{ENL} \end{bmatrix} \quad (3-85)$$

where the linear equations are the Taylor series equations and some of the boundary conditions. The purpose of the partitioning is to allow operations on sections of the coefficient matrix which result in significant simplification of the overall inversion. In particular, since the coefficients of the linear equations are all constant or functions of the fixed nodal spacing, this portion of the matrix (the AL portion) can be diagonalized once and for all in any given problem. In essence, the corrections on the linear variables ΔVL are always expressed in terms of the nonlinear variable corrections ΔVNL . The choice of linear and nonlinear labels for the variables is somewhat arbitrary, but care must be taken that the AL matrix not be singular. It has been found convenient to arrange the variables into the linear and nonlinear groups as follows: $\Delta \text{VL}_F (\Delta f_2, \Delta f_3, \dots, \Delta f_n, \Delta f_2'', \Delta f_3'', \dots, \Delta f_n'', \Delta f_1''', \Delta f_2''', \dots, \Delta f_n''')$; $\Delta \text{VL}_H (\Delta H_{Tn}, \Delta H_{T2}, \Delta H_{T3}, \dots, \Delta H_{Tn}, \Delta H_{Tw}, \Delta H_{T2}, \dots, \Delta H_{Tn})$; and $K-1$ sets of $\Delta \text{VL}_K (\Delta \tilde{K}_{kn}, \Delta \tilde{K}_{k2}, \Delta \tilde{K}_{k3}, \dots, \Delta \tilde{K}_{kn}, \Delta \tilde{K}_{kw}, \Delta \tilde{K}_{k2}, \dots, \Delta \tilde{K}_{kn})$. The nonlinear variables are then arranged in the following order: $\Delta \text{VNL}_F (\Delta \alpha_H, \Delta f_w, \Delta f_w'', \Delta f_1', \Delta f_2', \dots, \Delta f_n')$; $\Delta \text{VNL}_H (\Delta H_{Tw}, \Delta H_{Tw}, \Delta H_{T2}, \dots, \Delta H_{Tn-1})$; and $K-1$ sets of $\Delta \text{VNL}_K (\Delta \tilde{K}_{kw}', \Delta \tilde{K}_{kw}', \Delta \tilde{K}_{k2}, \dots, \Delta \tilde{K}_{kn-1})$. The order of the linear equations (L_p) in the present matrix procedure is:

<u>No. of Equations</u>	<u>Description of Equations</u>
$3N-2$	Linear boundary conditions and Taylor series for f, f', f'', f'''
$2N$	Linear boundary conditions and Taylor series for H_T, H_T', H_T''
$(K-1)(2N)$	Linear boundary conditions and Taylor series for $\tilde{K}_k, \tilde{K}_k', \tilde{K}_k''$

The nonlinear equation (NL_p) are sequenced as follows:

<u>No. of Equations</u>	<u>Description of Equations</u>
4	Nonlinear boundary conditions and α_H constraint
$N-1$	Momentum equation for each pair of nodes
N	Energy equation for each pair of nodes plus wall enthalpy equation
$(K-1)(N)$	$K-1$ sets of "elemental" species equations for each pair of nodes plus wall species equation

Special logic has been written for the matrix inversion, taking advantage of the regular sparseness of the matrix. Once the corrections for the linear and nonlinear variables are found, these corrections are added to the variables to form the new guesses. The magnitude of the errors for each equation are checked and the procedure advances to the next iteration if the absolute values of the errors exceed prescribed upper limits. If the errors are acceptable, iteration is completed for the current streamwise position ξ . Typically, three to six iterations are required to reach a satisfactory solution.

3.6 THE MATRIX REDUCTION PROCEDURE

Substantial savings in computation time and storage allocations can be realized if full advantage is taken of the ordered sparseness of the matrix of correction coefficients $[A]$. This is extremely important since the solution of a boundary layer with several elemental species would otherwise be very costly. For this reason the matrix solution procedure will be discussed in some detail.

In Section 3.5 the division of the variables and the equations in a linear and nonlinear group and the general form of the matrix were discussed. Figure 3-1 gives a more detailed representation of the matrix and clearly shows its regular sparseness. Here, for example, $[ANL_{pq}]$ and $[BNL_{pq}]$ are matrices representing the coefficients of the corrections $[\Delta VL_q]$ and $[\Delta VNL_q]$, respectively, arising from the nonlinear set of equations NL_p with the corresponding errors given by the single column matrix $[ENL_p]$, where p, q can be any of F, G , or K_i .

The first step in the matrix solution procedure is to invert the submatrices $[AL_{pp}]$ and to form the matrix products $[AL_{pp}]^{-1} [BL_{pp}]$ and $[AL_{pp}]^{-1} [EL_p]$ for $p = F, H$ and K . The former products have to be done only for $p = F$ and H since the linear equations relating the k^{th} elemental species to its derivatives (L_k) have the same form as the linear equations relating total enthalpy and its derivatives (L_H). Furthermore, this has to be done only at the beginning of the problem and after each refit as the matrices $[AL_{pp}]$ and $[BL_{pp}]$ depend only upon the boundary layer n -spacing.

The linear corrections $[\Delta VL_p]$ can then be expressed in terms of the nonlinear corrections $[\Delta VNL_p]$ and the linear errors $[EL_p]$ as follows:

$$[\Delta VL_p]_I = - [AL_{pp}]_{IxI}^{-1} [BL_{pp}]_{IxJ} [\Delta VNL_p]_J + [AL_{pp}]_{IxI}^{-1} [-EL_p]_I \quad (3-86)$$

where $I = 3N - 2$ and $J = N + 3$ for $p = F$, and $I = 2N$ and $J = N$ for $p = H$ or K with N the number of nodal points in the boundary layer. These can then be introduced into the nonlinear equations to yield the reduced problem:

$$[BNL]_{IxJ} [\Delta VNL]_J = [ENL]_I \quad (3-87)$$

AL_{FF}	0	0	0	0	0	0	0	0	0	BL_{FF}	0	0	0	0	EL_F
0	AL_{HH}	0	0	0	0	0	0	0	0	0	BL_{HH}	0	0	0	EL_H
0	0	$AL_{K_1 K_1}$	0	0	0	0	0	0	0	0	0	$BL_{K_1 K_1}$	0	0	EL_{K_1}
0	0	0	0	$AL_{K_2 K_2}$	0	0	0	0	0	0	0	0	$BL_{K_2 K_2}$	0	EL_{K_2}
0	0	0	0	0	0	$AL_{K_3 K_3}$	0	0	0	0	0	0	0	0	EL_{K_3}
ANL_{FF}	ANL_{FH}	ANL_{FK_1}	ANL_{FK_2}	ANL_{FK_3}	ANL_{FK_3}	ANL_{FK_3}	ANL_{FK_3}	ANL_{FK_3}	ANL_{FK_3}	ANL_{FK_3}	ANL_{FK_3}	ANL_{FK_3}	ANL_{FK_3}	ANL_{FK_3}	ENL_F
ANL_{HF}	ANL_{HH}	ANL_{HK_1}	ANL_{HK_2}	ANL_{HK_3}	ANL_{HK_3}	ANL_{HK_3}	ANL_{HK_3}	ANL_{HK_3}	ANL_{HK_3}	ANL_{HK_3}	ANL_{HK_3}	ANL_{HK_3}	ANL_{HK_3}	ANL_{HK_3}	ENL_H
$ANL_{K_1 F}$	$ANL_{K_1 H}$	$ANL_{K_1 K_1}$	$ANL_{K_1 K_2}$	$ANL_{K_1 K_3}$	$ANL_{K_1 K_3}$	$ANL_{K_1 K_3}$	$ANL_{K_1 K_3}$	$ANL_{K_1 K_3}$	$ANL_{K_1 K_3}$	$ANL_{K_1 K_3}$	$ANL_{K_1 K_3}$	$ANL_{K_1 K_3}$	$ANL_{K_1 K_3}$	$ANL_{K_1 K_3}$	ENL_{K_1}
$ANL_{K_2 F}$	$ANL_{K_2 H}$	$ANL_{K_2 K_1}$	$ANL_{K_2 K_2}$	$ANL_{K_2 K_3}$	$ANL_{K_2 K_3}$	$ANL_{K_2 K_3}$	$ANL_{K_2 K_3}$	$ANL_{K_2 K_3}$	$ANL_{K_2 K_3}$	$ANL_{K_2 K_3}$	$ANL_{K_2 K_3}$	$ANL_{K_2 K_3}$	$ANL_{K_2 K_3}$	$ANL_{K_2 K_3}$	ENL_{K_2}
$ANL_{K_3 F}$	$ANL_{K_3 H}$	$ANL_{K_3 K_1}$	$ANL_{K_3 K_2}$	$ANL_{K_3 K_3}$	$ANL_{K_3 K_3}$	$ANL_{K_3 K_3}$	$ANL_{K_3 K_3}$	$ANL_{K_3 K_3}$	$ANL_{K_3 K_3}$	$ANL_{K_3 K_3}$	$ANL_{K_3 K_3}$	$ANL_{K_3 K_3}$	$ANL_{K_3 K_3}$	$ANL_{K_3 K_3}$	ENL_{K_3}
ΔVL_F	ΔVL_H	ΔVL_{K_1}	ΔVL_{K_2}	ΔVL_{K_3}	ΔVNL_F	ΔVNL_H	ΔVNL_{K_1}	ΔVNL_{K_2}	ΔVNL_{K_3}						

Figure 3-1. Schematic of matrix equation relating the Newton-Raphson corrections on the primary variables to the errors for the mth iteration.

where $I = (K + 1) (N - 1) + 3$ and $J = (K + 1) N + 3$. The matrices \overline{BNL} and \overline{ENL} are formed from BNL and ENL in the following way:

$$\overline{BNL}_{pq} = BNL_{pq} - ANL_{pq} (AL_{qq}^{-1} BL_{qq}) \quad (3-88)$$

$$\overline{ENL}_p = ENL_p - \sum_q ANL_{pq} (AL_{qq}^{-1} EL_q) \quad (3-89)$$

This procedure significantly reduces the amount of information which must be stored. In fact, the only major blocks of coefficients which must be stored for representing all of the linear and nonlinear equations are $[AL_{qq}^{-1}] [BL_{qq}]$ which is $3N - 2$ by $N + 3$ for $q = F$ and $2N$ by N for $q = H_T$ or K , and \overline{BNL} which is $[(K + 1) (N - 1) + 3]$ by $[(K + 1) N + 3]$ where N is the number of nodes and K is the number of species. This is contrasted with the size of the complete matrix of coefficients which is $3KN + 4N + 1$ square. (For a 2-element, 12-node problem this represents a savings of about 12,000 storage spaces, and for the largest possible problem, 7 elements and 15 nodes this is a savings of about 123,000 locations.)

The matrix Equation (3-87) is substantially reduced further as follows. First, the columns are rearranged so that the nonlinear corrections can be divided into two sets: $\Delta VNL_a (\Delta \alpha_H, \Delta f'_w, \Delta f'_2, \dots, \Delta f'_n, \Delta H'_{Tw}, \Delta H'_{T2}, \dots, \Delta H'_{Tn-1}, \Delta \tilde{K}'_{kw}, \Delta \tilde{K}'_{k2}, \dots, \Delta \tilde{K}'_{kn-1})$ and $\Delta VNL_b (\Delta f_w, \Delta H_{Tw}$ and the $\Delta \tilde{K}_{kw}$). Equation (3-87) can then be expressed as

$$\begin{bmatrix} \overline{BNL}_a & \overline{BNL}_b \end{bmatrix}_{I \times J} \begin{bmatrix} \Delta VNL_a \\ \Delta VNL_b \end{bmatrix}_J = \begin{bmatrix} \overline{ENL} \end{bmatrix}_I \quad (3-90)$$

where \overline{BNL}_a is a square matrix, being the coefficients of the I corrections $[\Delta VNL_a]$, with $I = (K + 1) (N - 1) + 3$ and $J = (K + 1) N + 3$. Utilizing the same matrix reduction procedure employed previously (in going from Equation (3-85) to Equation (3-87)), the $[\Delta VNL_a]$ can be expressed in terms of the reduced set of corrections $[\Delta VNL_b]$ as

$$[\Delta VNL_a]_I = - [\overline{BNL}_a]_{I \times I}^{-1} [\overline{BNL}_b]_{I \times J} [\Delta VNL_b]_J + [\overline{BNL}_a]_{I \times I}^{-1} [\overline{ENL}]_I \quad (3-91)$$

where $I = (K + 1) (N - 1) + 3$ and $J = K + 1$.

The reduced set of nonlinear corrections $[\Delta VNL_b] (\Delta f_w, \Delta H_{Tw}$ and the $\Delta \tilde{K}_{kw})$ are obtained from a consideration of the nonlinear wall boundary conditions. Once these

are determined, the remaining nonlinear corrections $[\Delta VNL_a]$ are obtained directly by use of Equation (3-91). The linear corrections $[\Delta VNL_p]$ are then calculated using Equation (3-86). These linear and nonlinear corrections are then added to the corresponding primary variables in accordance with Equation (3-63), thus completing the m^{th} iteration. The magnitude of the errors are checked and the procedure advances into the $m+1^{th}$ iteration if the absolute errors exceed prescribed upper limits. If not, the iteration is completed for the current value of the streamwise position ξ .

SECTION 4

PROGRAM DESCRIPTION AND LISTING

This section contains a discussion of machine requirements and the overlay structure useful for reducing core storage. A flow chart and verbal description of the solution process are presented with a verbal description of the function of each subroutine. A complete listing of the program and the Fortran variables are also given. This information and that presented in Sections 2 and 3 should enable the interested and persistent user to better understand the solution procedure and logic.

4.1 MACHINE REQUIREMENTS

The BLIMP program has been used on Univac 1108, CDC 6600, CDC 7600, and various IBM machines. The current version, BLIMP-J, has been extensively used only on the Univac 1108; however, only minor adjustments should be required for useage on other machines. (For IBM equipment it is desirable to double precision certain variables.) The amount of storage required depends, of course, on the size of the words for each machine and the efficiency of the compiler. Typical numbers are given below in decimal words (octal words).

	Univac 1108 EXEC 8	CDC 7600 FTN Version 2
Program size, without overlay	71,398 (213 346)	61,440 (170 000)
Program size, with overlay	56,557 (156 355)	53,248 (150 000)

A recommended overlay structure is shown in Figure 4-1. On CDC equipment it is best to use the minimum overlay structure compatible with storage requirements. On all machines the core should be set to zero before execution.

The following unit assignments are built into the program:

READ — KIN-5
WRITE — KOUT-6
PUNCH — KPCH-7
PLOT — KPLT-18
SCRATCH — NBT-19
SCRATCH — NBT2-20

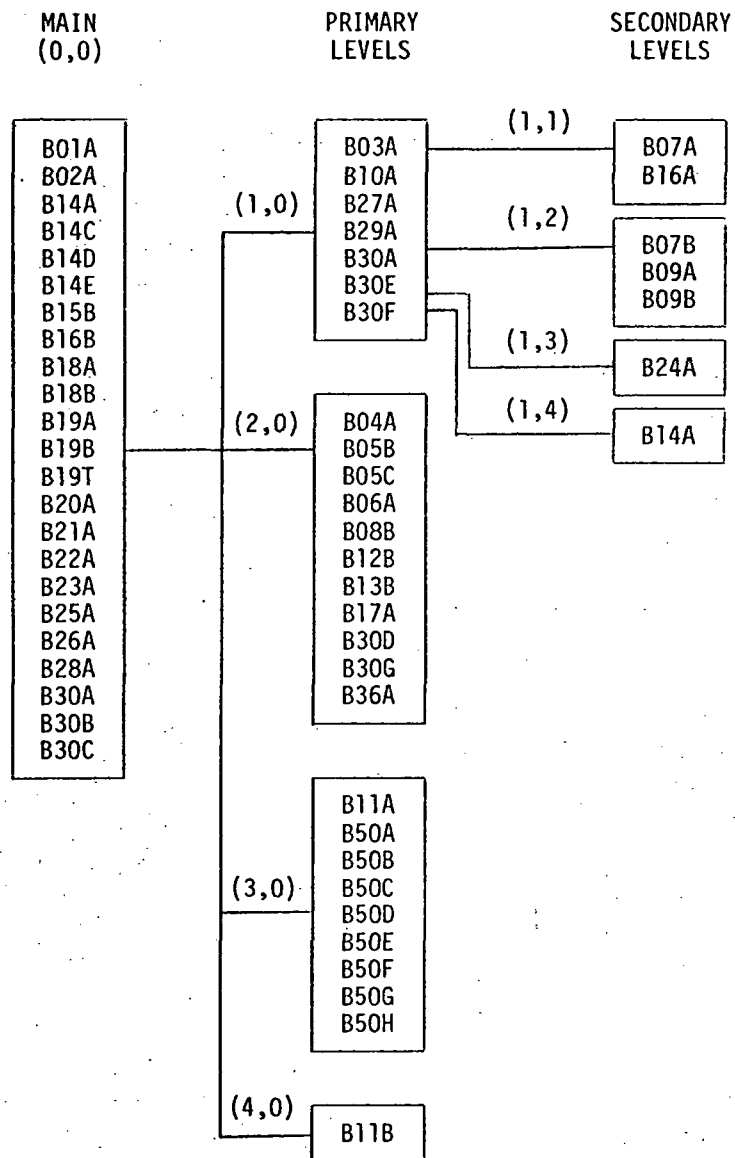


Figure 4-1. Overlay structure for BLIMP-J.

These assignments can be changed by changing the appropriate unit variable (ex. KOUT) in B02A.

4.2 DESCRIPTION OF SUBROUTINES

The BLIMP-J subroutines are identified by two labels. The first label is the element name and the second label is the subroutine name, e.g., B03A (element name), SETUP (subroutine name). In the following description the subroutines are ordered according to their element name. Figure 4-2 gives a flow chart which shows the general solution procedure and the interconnection of the major subroutines.

There are several dummy subroutines included in the program. Some of these are for obtaining information from the computer system, e.g., date, time of day, etc. The specific routines are B30B, B30D, B30E, B30F, B30E. They are described on the following pages. If there are system subroutines of the same name and function they may be removed from the program. Alternately, they may be used to call the appropriate system routine.

B01A DUMCOM

A collection of all labeled commons sometimes useful when performing debug operations. (Serves as main program for CDC machines. Calls BLIMP (B02A).)

B02A BLIMP

Master calling program. For the Univac system, this program calls SETUP, ITERAT, OUTPUT, ROCOUT. (For CDC this is a subroutine called by DUMCOM.)

B03A SETUP

Control program for setting up boundary layer edge conditions and streamwise derivatives for a new station or a new case. Called by BLIMP. Calls FIRSTG, LINMAT, RECASE, TRMBL, STATEN, REFCN, TRANC, HISTXI, INPUT, TOD, ETIMEF, DATE.

B04A ITERAT

Control program for performing boundary layer iteration and testing maximum errors for convergence. Called by BLIMP. Calls NNNCER, ETIMEF, NONCER, TLEFT.

B05A NNNCER (entry point NONCER)

Control program for performing that portion of a boundary layer iteration having to do with solution of the nonlinear (conservation) equations. With the aid of its subroutines, it evaluates errors and coefficients of the corrections of the nonlinear equations, reduces this matrix to the nonlinear set, evaluates maximum

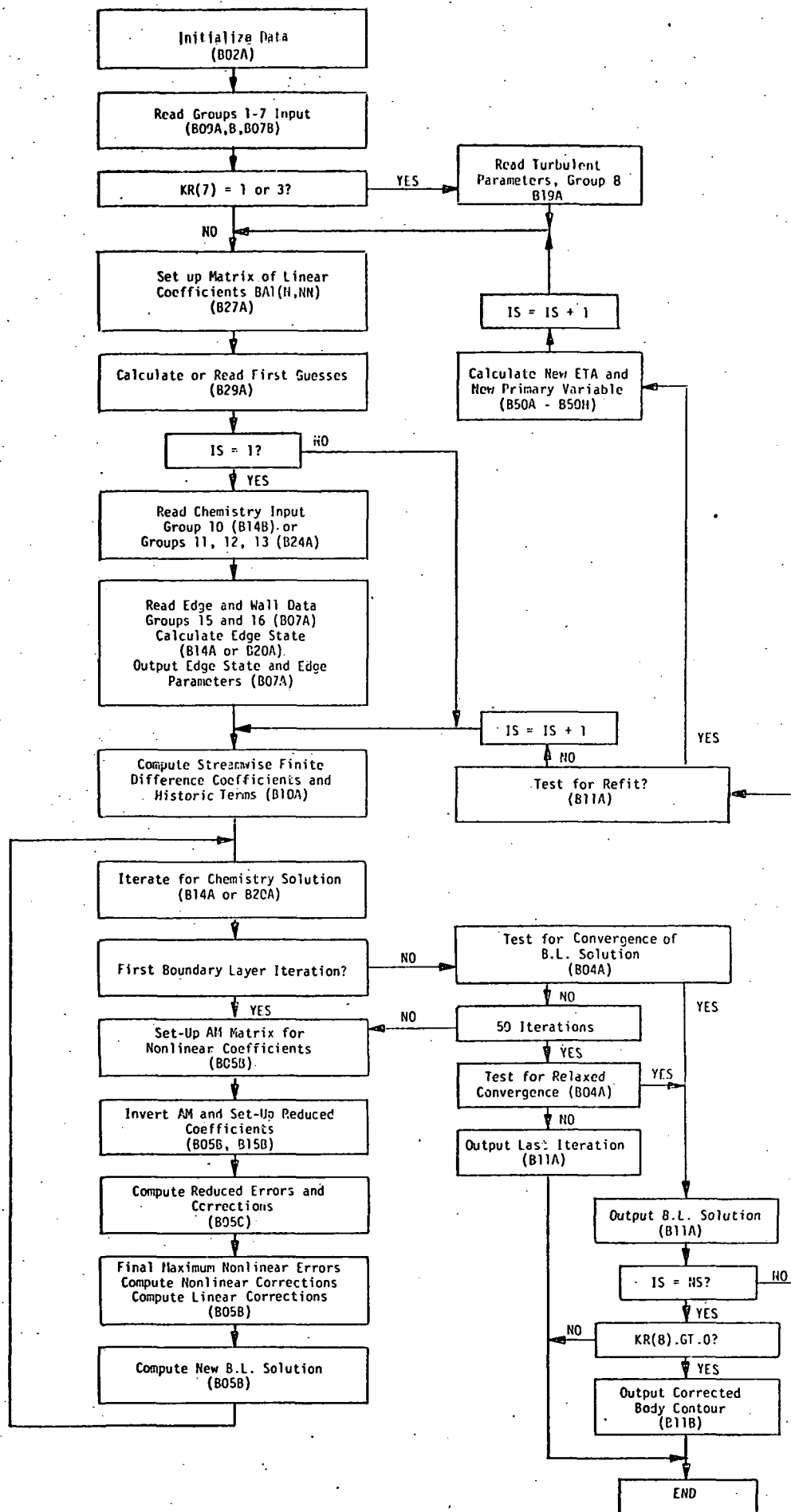


Figure 4-2. Flow chart for BLIMP-J solution procedure.

errors of conservation equations, evaluates corrections, computes damping factor and applies to corrections, and corrects primary variables. Called by ITERAT. Calls IMONE, EQUIL, ICOEFF, IONLY, RERAY, ABMAX, RNLCE, STATE, OGLE, LINCER, TRMBL, TRANC, LIAD, ETIMEF.

B05A RNLCE

Further reduces nonlinear equations to reduced nonlinear set of wall variables. Introduces wall boundary conditions and solves for new values of this set. Called by NNNCE. Calls RERAY, EQUIL.

B06A LINCER

Evaluates errors for linear equations (i.e., Taylor series expansions and linear boundary conditions) and with the aid of its subroutines, determines maximum errors of linear equations and corrects errors for these linear equations for the matrix reduction which is performed on the linear equations (see discussion under subroutine MATS1). Called by NNNCE. Calls ABMAX, MATS1, MATS2.

B07A REFCN

Calculates boundary layer edge conditions and sets up wall boundary conditions for uncoupled problems. Called by SETUP. Calls STATE, EQUIL, SLOPQ, SLOPL.

B07B MISCIN

Sets up default values for certain variables and reads namelist \$MISLIS. Called by RECASE.

B08B ICOEFF

Calculates groupings which contribute to the error equations and influence coefficients for the nonlinear (conservation) equations. Called by NNNCE.

B09A RECASE

Reads in most of boundary layer input data. Called by SETUP. Calls TOD, DATE, GEOM.

B09B GEOM (S, R, P, KIN, NBT, NBT2, NS, PTET, NTH, GE, IP, IU)

Reads namelist \$INPUT and computes the wall length and the gradients of pressure and velocity when necessary. Selects from the input data those stations used for boundary layer solution stations. Called by RECASE.

S -- wall length

R -- nozzle radius

P -- pressure

KIN,NBT,NBT2 -- unit assignments

NS -- number of BLIMP solution stations

PTET -- axial coordinates of BLIMP solution stations

NTH -- throat station number

GE -- $\cos \phi$ (wall angle)

IP -- flag for input of edge pressure and edge pressure gradient

IU -- flag for input of edge velocity and edge velocity gradient

$$s_i \text{ (wall length)} = s_i + \sum_{j=2}^{NP_i} [(r_j - r_{j-1})^2 + (x_j - x_{j-1})^2]^{1/2}$$

$$\phi_i = \arctan \left(\frac{r_j - r_{j-1}}{x_j - x_{j-1}} \right), \quad j = NP_i$$

for IP = 1

$$\left. \frac{dP}{dx} \right|_i = \frac{1}{2} \left[\frac{P_{j+1} - P_j}{x_{j+1} - x_j} + \frac{P_j - P_{j-1}}{x_j - x_{j-1}} \right], \quad j = NP_i$$

for IU = 1

$$\left. \frac{dU_e}{dx} \right|_i \quad \text{same as} \quad \left. \frac{dP}{dx} \right|_i \quad \text{with } P \text{ replaced by } U_e$$

where i -- BLIMP solution station
 j -- index on input x, r, P, etc.
 NP_i -- value of j for the ith BLIMP solution station

B10A HISTXI

Computes terms involving derivatives with respect to XI (i.e., nonsimilar terms) and stores those upstream quantities needed for these difference relations. Called by SETUP. Calls TAYLOR.

B11A OUTPUT

Prints standard boundary layer output block for converged solution or, if required, at the end of each iteration. Called by BLIMP. Calls REFIT.

B11B ROCOUT

Available as an option (KR(8) = 1,2,3), this subroutine calculates a corrected body contour which can be output onto punched cards for use as input to TDK.

The KR(8) = 1 option calculates and punches the inviscid flow contour which should be used for TDK input for a specified, and different, nozzle contour (which has been input to BLIMP-J). The inviscid contour is calculated from

$$R_I = R_B - \delta_B^* \cos \phi$$

$$X_I = X_B + \delta_B^* \sin \phi$$

where R_I is the inviscid contour radius, R_B is the nozzle radius (input), δ_B^* is the body displacement thickness, and ϕ is the wall angle.

The KR(8) = 2 option calculates and punches the desired body contour if the input contour is the inviscid flow field contour. The body contour is calculated from

$$R_B = R_I + \delta_B^* \cos \phi$$

$$X_B = X_I - \delta_B^* \sin \phi$$

where the terms are the same as above except that R_I is the input contour to BLIMP.

In both cases the contour is normalized to the throat radius (the minimum radius) and the axial coordinate is zero at the throat. Also, the contour is punched in a form suitable for TDK input.

B12B IMONE

Evaluates the coefficients of the $(I-1)^{th}$ corrections for the I nonlinear (conservation) equations, where I is the I^{th} nodal point in the boundary layer. Called by NNN CER. Calls TAYLOR, LIAD.

B13B IONLY

Evaluates the coefficients of the I^{th} corrections for the I^{th} nonlinear (conservation) equations, where I is the I^{th} nodal point in the boundary layer. Called by NNN CER. Calls LIAD.

B14A STATE

Evaluates the chemical state and properties of a homogeneous gas mixture.
Called by NNNCER, REFCON. Calls HHOMO, CHOMO, SHOMO.

B14B STATEN

Reads in basic property data for homogeneous boundary-layer option. Called by SETUP.

B14C HHOMO(T)

Calculates enthalpy of homogeneous gas at temperature T, degrees R. Called by STATE.

B14D CHOMO(T)

Calculates specific heat of homogeneous gas at temperature T, degrees R. Called by STATE.

B14E SHOMO(T)

Calculates entropy of homogeneous gas at temperature T, degrees R. Called by STATE.

B15B RERAY (N, C, NQ, D, NQN, NNN, LS, IS, ND, SD, L, S, LL, LLL)

Replaces rectangular matrix (C) with N rows and N+NQ columns by the product of the inverse of an N by N submatrix and the remaining columns of C. The inverse is also permitted to act on additional columns (matrix (D) with ND rows and NQN columns) from another portion of memory. Also, routine rearranges columns according to arbitrary specifications given by LS.

$$N \begin{bmatrix} N & NQ \\ C & \end{bmatrix} \begin{bmatrix} NQN \\ D \end{bmatrix} ND$$

Called by EQUIL, NNNCER, RNLCER.

N = number of rows in rectangular matrix (see sketch)

C = elements of rectangular matrix (see sketch)

NQ = number of columns in matrix C in excess of those contributing to square matrix (see sketch)

D = elements of matrix of additional columns (see sketch)

NQN = number of additional columns (see sketch)

LS = sequence to which columns of C are rearranged (LS(1) = 0 signifies no rearrangement)

IS = flag, yields debug output if RERAY entered with IS = -2, signifies singular matrix if RERAY yields IS less than zero

ND = dimension on rows of C from calling program

SD-LLL used to bring in dummy storage space

B16A SLOPQ (N, X, Y, S, Z)

Based on a sequence of quadratic (3-point) fits of a set of points, calculates average slope at each point and integrates the equation thus defined between each pair of points. Called by REFCN.

N = number of points to be considered

X = abscissa at each point

Y = ordinate at each point

S = derivative at each point

Z = integral up to each point

B16B SLOPL (N, X, Y, S, Z)

This routine performs the same function as B16A SLOPQ except that linear (2-point) fits are used instead of quadratic (3-point) fits. The slope is the average of the left and right slopes. Called by REFCN, TRANC.

B17A ABMAX (N, X, XM, I)

Searches an array for the entry with maximum value. Called by LINCER, NNNCR.

N = number of entries in the array

X = coefficients in array under consideration

XM = entry with maximum absolute value

I = index on XM

B18A MATS1(X)

Performs operations on a column of a matrix B or on a column of errors R (designated X in call list) such as to form $A^{*(-1)}X$ where $A^{*(-1)}$ is the inverse

of the sparse matrix formed from the Taylor series expansions of $F(1,I)$ and their derivatives (in the case of MATS1) and of $G(1,I)$ or $SP(1,I,K)$ and their derivatives in the case of MATS2), viz.,

Original matrix equation

$$(A + B)V = R$$

multiplying through $A^{**(-1)}$

$$[1 + A^{**(-1)}*B]V = A^{**(-1)}*R$$

Called by LINCER, LINMAT, MATS2.

B18B MATS2(X)

See MATS1 for function. Called by LINCER, LINMAT, FIRSTG. Calls MATS1.

B19A TRMBL(ILK)

Evaluates turbulent transport properties and their derivatives with respect to nonlinear variables. Called by SETUP, NNNCER. Calls LIAD, TAYLOR, ERP, ERF.

B19B ERF(X)

Calculates the error function of X. Called by TRMBL.

B19T TRANCER

Evaluates terms required for consideration of transverse curvature. Called by SETUP, NNNCER.

B20A EQUIL (KQ, Z, PRR)

Control program for computation of chemical state of the system. Performs such complex functions as setting up for different types of solutions (isentropic expansion, stagnation point, boundary layer or wall), recalling stored values of boundary layer solutions and reinitializing omitted species, re-evaluating absent atom array, deleting molecules based on absent atom array, and, with the aid of subroutines, evaluating properties, controlling principal iterative loop, and reinverting and attempting alternate paths when convergence problems occur. Called by NNNCER, REFCOR, RNLCE. Calls CRECT, MATER, PROPS, RERAY, THERM.

KQ = flag which controls chemistry options (see Fortran variables list)

Z = enthalpy (when used)

PRR = pressure

B21A THERM

Evaluates current thermodynamic properties for each species, which data are required for evaluation of errors and correction coefficients in chemistry solution. Called by EQUIL.

B22A MATER

Evaluates current errors in chemistry solution and sets up matrix of linearized correction equations. Called by EQUIL. Calls KINET.

B23A CRECT(MOE)

Corrects state variables and composition, principal logic being involved with limiting corrections such that instabilities in the iterations will not occur. Called by EQUIL.

MOE = 0 or 1 if linearization done predominantly on equilibrium or mass balance relations, respectively.

B24A INPUT

Reads in basic elemental composition data and species property data, selects base species, and sets up stoichiometric coefficients for species formation reactions. Called by SETUP.

B25A PROPS

Computes all properties and property derivatives required by boundary layer calculations. Called by EQUIL.

B26A TAYLOR (D, FM, F, P)

Calculates coefficients in Taylor series expansions of integrals which appear in the integral form of the boundary layer equations. Called by HISTXI, IMONE, TRMBL.

D = distance between neighboring nodes I and I-1

FM = value of function and its derivatives at I-1

F = value of function and its derivatives at I

P = terms in Taylor series expansion.

B27A LINMAT

Sets up matrices for Taylor series expansions and linear boundary conditions from eta spacing, and solves to express linear corrections in terms of nonlinear corrections. Called by SETUP. Calls MATS1, MATS2.

B28A KINET

The subroutine is reserved for modeling of kinetically controlled surface reactions. Called by MATER.

B29A FIRSTG

Computes or reads in first guesses for primary variables or instructs program to use values from previous case. Called by SETUP. Calls MATS2, MATS1.

B30A ERP(X)

Forms Dawson integral of X. Called by TRMBL.

B30B ETIMEF(T) (entry point ETIME)

Subroutine to call the system for elapsed time, T, in seconds. Present routine calls the system by a call SECOND. This call should be replaced with the appropriate system call, or the entire subroutine can be replaced by a dummy. Called by SETUP, ITERAT, NNN CER.

B30C LIAD (L, I, J, C)

Alters elements of the AM matrix and the corresponding errors to reflect the solutions to the linear equations. Called by NNN CER, IMONE, IONLY, TRMBL.

L = -1 for momentum, 0 for enthalpy, and K for species equations

I = Ith nonlinear equation

J = Jth linear variable

C = coefficient of Jth linear variable in Ith nonlinear equation

B30D TLEFT(I)

Dummy subroutine. Not used with BLIMP-J. Called by ITERAT.

B30E DATA (I, J)

Dummy subroutine. Can be replaced with a call to the system for date. Called by SETUP, RECASE.

I = 9

J is dimensioned 3 and is expecting a format of 3A6. The first 9 locations are filled by DATE and the second 9 locations by TOD.

B30F TOD (I, J)

Dummy subroutine. Can be replaced with a call to the system for time of day. Called by SETUP, RECASE.

I = 18

J = see B30E

This subroutine and B30E fill the J(3) with information giving date and time of day.

Example: 10 AUG 74 10:23:02

B30G SECOND(T)

Dummy subroutine. Called by ETIMEF.

B36A OGLE (N, XAM, PRM, DPDIM, NUMX, X, P, EM)

Looks up an array of values of a single dependent variable using a cubic curve fit between any two points (and corresponding two slopes) of the table. Called by NNNCER.

N = number of points to be considered

XAM = value of independent variable for which lookup is to be performed

PRM = output interpolated values returned by OGLE

DPDIM = output interpolated slopes returned by OGLE

NUMX = number of tabular entries in the table

X = tabular independent variable

P = tabular dependent variable

EM = slopes to be used

B50A FILQ3

This routine converts the coordinate and constraint data into elements in the solution matrix and sets up this matrix for FINEQ. Called by FISLEQ. Calls FUNXS, TRINT.

B50B FILQ5

This routine evaluates values of variables and their derivatives at new nodes. Called by FISLEQ. Calls FUNXS.

B50C FINEQ

This routine solves for the unknown coefficients of the new polynomial segments based on LU matrix decomposition. Called by FISLEQ.

B50D FISLEQ

This is the main subroutine for least square curve fits of variables between nodal points. Called by POINTS. Calls FILQ3, FINEQ, FILQ5.

B50E FUNXS

This routine evaluates special polynomials for the refitting function. Called by FILQ3, FILQ5.

B50F TRINT

This routine evaluates special polynomials for the refitting function. Called by FILQ3.

B50G POINTS

This routine uses current values of the variables and their derivatives and solves for the coefficients of the polynomial segments between each pair of adjacent nodes. Limits placed on the velocity variable establish the new nodal distribution and values of remaining variables and their derivatives are calculated for this new distribution. Called by REFIT. Calls FISLEQ.

B50H REFIT

This is the main calling routine for the refit procedure. It evaluates certain constraints which depend on NETA and the type of curve fit. The B50 subroutines are all part of the REFIT option. Called by OUTPUT. Calls POINTS.

4.3 PROGRAM LISTING

B01A. DUMCOM

```

1.      C      B01A
2.      SUBROUTINE DUMCOM(ICK)
3.      COMMON/BLQCOM/ MOA( 60), MOB( 60),NSPEC,FR( 60,15),W(3),LEF( 8)
4.      1,LEFS( 8),PIEASE,LEFW( 8),L2,L3
5.      COMMON/BUMCOM/ BUMP,CORMA,EASE,ICORM,WDOT,TFZ,I777,DTEMP,KIP,IX
6.      COMMON/COECON/ C5,C6,C7,C8,C9,C10,C11,C12,C13,C14,C15
7.      1,C16,C17,C18,C19,C20,C21,C22,C23,C24,C25,C26,C27,C28,C29,C30,C31,C
8.      232,C33,C34,C35,C36,C37,C38,C39,C40,C41,C42,C43,C44,C45,C46,C47,C48
9.      3,C49,C50,C51,C52,C53,C54,C55,C56,C57,C58,C59,C60,C61,C62,C63,C64,C
10.     465,C66,C67,C68,C69,C70,C71,C72,C73,C74,C75,C76,C77,C78,C79,C80,C81
11.     5,C82,C83,C84,C85,C86,C87,C88
12.     COMMON/COECON/ CK1( 6),CK2( 6),CK3( 6),CK4( 6),CK5( 6),CK6( 6)
13.     1,CK7( 6),CK8( 6),CK9( 6),CK10( 6),CK11( 6),CK12( 6),CK13( 6)
14.     2,CK14( 6),CK15( 6),CK16( 6),CK17( 6),CK18( 6),CK19( 6),CK20( 6)
15.     3,CK21( 6),CK22( 6),CKK1( 6, 6),CKK2( 6, 6),XM(5),XG(5),XSP(5, 7)
16.     4,CKK3( 6, 6)
17.     COMMON/CRBCOM/HCARB,EMIS,STEF,ADUM,BDUM,CDUM,HTEF,HMAT,EMISC,EMIST
18.     1,HPG,ASU(3),BSU(3),HPYG(3),HCHAR(3),EMIV(3),KS(40),ISU
19.     COMMON/EDGCOM/ PE(40, 1),PTE(40, 1),SPE( 6,40, 1),DUES,
20.     1UE(40),RHOE(40),VMUE(40),TE(40),UEDGE,DUEDGE,D2UEDG,VMWF,HE,C90
21.     2,DSIP(40),IDSIP,TTVC,TVCC(40),HEA(40),SF(20),CS(20),CSPR(20),
22.     3CG(20),CGP(20),SREF,GEP,NEN,UNF,RHOINF,HINF,PINF
23.     COMMON/EPSCOM/ELCON,YAP,CLNUM,SCT,PRT,RED,DVS,RHOVS,PI,PIM,CL,
24.     1 EPSA(15),EPS1,EL(15),DPI(15,2),DEPC,TREF,RETR
25.     2,VINTR(15)
26.     COMMON/EGPCOM/RB(60,3),RC(60,3),RD(60,3),RE(60,3),RF(60,3),RG(60,3
27.     1),TU(60,3),FF(60),FFA,IFC(60),ATA(8),ATB(8),ATC(8),WAT(8),PA(60,3)
28.     3,
29.     2 KAT( 8),IR( 8),IZ,KZ(10),LAMI( 60),P,Z,TK( 8, 8),VN( 60),
30.     3 VNU( 60, 8),ITFF,KR2,HCH,NCV,WM,WTM( 60),YYY( 60),YW( 60),GC( 60)
31.     4,TQ( 8, 8),EPOVRK,SIGMA,BASMOL
32.     COMMON/EQTCOM/SIP,HIP,EEL,EENL,FLIQ,CPF,IRE,IER,AA,IITS,IN,IL,IIT,
33.     1 MODE,HMELT,8MELT,TMAX,TMIN,MELT,SUMN,SUML,WS,WSS,RX,ISP2,ISPO,
34.     2 ISP,KKJ,SVA,SVB,SVC,SVD,SUMC,FFF,CMF,EP,RV,IFCJC,WTG,WTL,JC,HMG,
35.     3 CPG,TMIN,TMAX,L7,L8,IB( 9),EB( 8),EBL( 8),A(14,14),RB(14),
36.     4 IP( 60),ALP( 8),FNU( 8),GAMH( 8),GAMF( 8),SLAM( 8),DY( 60),RVS,
37.     5 CP( 60),HH( 60),SB( 60),TC( 60),VLNK( 60),E( 60),PNUS( 8),
38.     6 BC( 8),BLNK( 8),BY( 8),IRC( 8),BE( 8),JZ( 4)
39.     COMMON/ERRCOM/FLE( 43),GLE(30),SPLE(30, 6),ELA(253),FLEM,GLEM
40.     1,SPLEM( 6),ELM(14),ELMM,IFLM,IGLM,ISPLM( 6),NELM,ILMM,DFL(43)
41.     2,DGL(30),DSPL(30, 6),FNLE(18),GNLE(15),SPNLE(15, 6),ENL(123)
42.     3,FNLEM,GNLEM,SPNLEM( 6), ENLMM,IFNLM,IGNLM,ISPNLM( 6)
43.     4,NENLM,INLMM,DFNL(18),DGNL(15),DSPNL(15, 6),DRNL( 8)
44.     COMMON/ETACOM/ETA(15),DETA(15),DSQ(14),DCU(14),B1(14),B2(14)
45.     1,LAR(123),BA1(43,18),BA2(30,15)
46.     COMMON/FLPCOM/ LEFT( 8,2)
47.     COMMON/FLXCOM/DELQW,DELJW(6),WALLQ,WALLJ(6),QW,VJKK(7),TPWALL
48.     COMMON/HISCOM/C1,C2,C3,C4,ALPHD,BETA,ZH(4,14),ZG(4,14),ZSP(4,14, 6
49.     1),XI(40),HF(15,5),HG(15,3),HSP(15,3, 6),HALPH,HUE,HWUE,HFW,DLX2
50.     2,C3M(40),BETAM(40)
51.     3,BETAV(40)
52.     COMMON/INTCOM/ KR(20),KIN,KOUT,MAT1I,MAT2I,MAT1J,MAT2J,NETA,I,IS,N
53.     1S,IT,NTIME,NSP,NSPM1,NAH,NLEQ,NNLEQ,NRNL,ITS,KAPPA,CBAR,CASE(15)
54.     2,B(8), MWE,NON,KQ(10),ITEM,NITEM,KR17,NRT,NRT2,IDENT,KR9(40)
55.     3,KAUXO,JTIME,JSPEC,MD(3),IU,ISH
56.     4,KONRFT
57.     COMMON/KINCOM/MT,FKF(10),EAK(10),EXK(10),PMU( 8,10),RMU( 8,10),
58.     1 DKPT(10),PKP(10),PKR(10),RAT(10),RSIG(10),MA(10),LL(10),PMR(10),
59.     2 PRMU( 8,10),EASE( 8)
60.     COMMON/NONCOM/AM(123,123),DVNL(123),TCW,
61.     1VLNKH,DLPH( 7),DLPK( 6, 7),DTHW,DTKW( 6),FLUXJB( 7)

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62. COMMON/OUTCOM/Y(15),RES,DELST,THENGY,THMOM,CH,BLOW,SHEAR,CF,SHAPE
63. 1,CM( 7),THELEM( 7)
64. COMMON/PRMCOM/TIME( 50),PRE(40),PTET( 50),GE( 50),S(40),ROKAP(40)
65. 1,RNOSE,VKAP,NOISC,IDISC(40),NSD(5),MSD(5),ITF( 50),IPRE,RADNO,CONE
66. 2,RADFL( 50),RADR(40),RADS(40),IRAD
67. COMMON/PRPCOM/PR(15),T(15),RHO(15),SC(15),CAPC(15),QR(15),H(15)
68. 1,CPBAR(15),VMW(15),PHIK(15, 6),DRHOM,DRHOK( 6),ZK( 6),DZKH( 6), D
69. 2MU3K( 6),DMU4K( 6),DTK( 6),DPHIK( 6),DPRK( 6),DSCK( 6),DCAPCK( 6)
70. 3,DHTILK( 6),DGRK( 6),DCPBK( 6),DCPTK( 6),DMU12K( 6),DZKK( 6, 6)
71. 4,DPHIK( 6, 6), DMU4H,DMU3H,DHTILH,VMU12,CT,CTR,CPTIL,HTIL
72. 5,VMU3,DTH,DCAPCH,DPRH,DSCH,DGRH,DCPBH,DCPTH,DMU12H,VMU(15), RHOP
73. 6(15),PHIKP(15),HP,TP,ZKP( 6),VMU3P,VMU4P,HTILP,CRHO(14),GMR(15)
74. COMMON/RFTCOM/F2FIX(15),DUM5(3),RATLIM,UKAPPA(15),
75. 1 KTURB,KAPPAT,NETAT,F2FIXT(15),NETAL,KAPPAL
76. COMMON/STCOM/GAM1,PRDUM,PRA,PRB,PRC,PRD,VMUA,VMUB,VMUC,VMUD,NC,
77. 1 FLD(7,3),VMWO,TR(3),L
78. COMMON/TEMCOM/SPDUM( 6),DER(40),DUMM1(15),SLOPE(15),REDUM(15)
79. 1,SDUM1(40),SDUM2(40),FWDUM(40),XICON(40),FWCON(40),FWINIT( 1)
80. 2,XIINIT( 1),DUDS( 40)
81. COMMON/TURB/ STURB,DELCON,DCLNUM,TURPR(15)
82. COMMON/UNICOM/UCFSI(9),ITDK,IUNIT,IPLT,KA(2,19)
83. COMMON/VARCOM/F(4,15),G(3,15),SP(3,15, 7),ALPH
84. COMMON/WALCOM/FW(40, 1),TW(40, 1),HW(40, 1),SPW( 6,40, 1)
85. 1,RHOVW(40, 1),FLUXJ( 3,40, 1),IHW,ITW,IFW,ISPW,IRHOVW,IFLUXJ
86. EQUIVALENCE (FLPEQV,TXI),(BLGEQV,MOA),(BUMEQV,BUMP),(COEEQV,C5),
87. 1(CONEQV,CK1),(CRBEQV,HCARB),(EDGEQV,PE),(EQPEQV,RB),(EPSEQV,ELCON)
88. 2,(KINEQV,MT),(EQTEQV,SIP),(ERREQV,FLE),(ETAEQV,ETA),(HISEQV,C1),
89. 3 (INTEQV,KIN),(NONEQV,AM),(PRMEQV,TIME),(PRPEQV,PR),(STTEQV,GAM1),
90. 4 (TEMEQV,SPDUM),(VAREQV,F),(WALEQV,Fw),(FLXEQV,DELOW),(OUTEQV,Y)
91. DATA ATA(1),ATB(1),ATC(1)/4H ,4H ,4H /
92. IF (ICK-101) 70,10,40
93. 10 READ( 12 ) FLPEQV,BLGEQV,BUMEQV,COEEQV,CONEQV,CRBEQV,EPSEQV,
94. 1 EDGEQV, EQPEQV, KINEQV, EQTEQV, ERREQV, ETAEQV,
95. 2 FLXEQV, HISEQV, INTEQV, NONEQV, OUTEQV, PRMEQV,
96. 3 PRPEQV, STTEQV, TEMEQV, VAREQV, WALEQV
97. GO TO 70
98. 40 WRITE(12 ) FLPEQV,BLGEQV,BUMEQV,COEEQV,CONEQV,CRBEQV,EPSEQV,
99. 1 EDGEQV, EQPEQV, KINEQV, EQTEQV, ERREQV, ETAEQV,
100. 2 FLXEQV, HISEQV, INTEQV, NONEQV, OUTEQV, PRMEQV,
101. 3 PRPEQV, STTEQV, TEMEQV, VAREQV, WALEQV
102. 70 CONTINUE
103. 5 RETURN
104. END

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BO2A, BLIMP

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1. CBI IMP          BOUNDARY LAYER INTEGRAL MATRIX PROCEDURE
2. COMMON/BLQCOM/  MOA( 60),  MOB( 60),NSPEC,FR( 60,15),W(3),LEF( 8)
3. 1,LEFS( 8),PIEASE,LEFW( 8)
4. COMMON/INTCOM/  KR(20),KIN,KOUT,MAT1I,MAT2I,MAT1J,MAT2J,NETA,I,TS,N
5. 19,IT,NTIME,NSP,NSPM1,NAM,NLEQ,NNLEQ,NRNL, ITS,KAPPA,CBAR,CASE(15)
6. 2,B(8),          MWE,NON,KQ(10),ITEM,NITEM,KR17,NBT,NBT2,IDENT,KR9(40)
7. 3,KAUXO,JTIME,JSPEC,MO(3),IU,ISH
8. COMMON/PRMCOM/TIME( 50),PRE(40),PTET( 50),GE( 50),S(40),ROKAP(40)
9. 1,RNOSE,VKAP,NDISC,IDISC(40),NSD(5),MSD(5),ITF( 50),IPRE,RADNG,CONE
10. 2,RADFL( 50),RADR(40),RADS(40),IRAD
11. COMMON/UNICOM/UCD,UCE,UCL,UCM,UCP,UCR,UCS,UCT,UCV,ITOK
12. 1,IUNIT,IPLT,KA(2,19)
13. COMMON/WALCOM/FW(40, 1),TW(40, 1),HW(40, 1),SPW( 6,40, 1)
14. 1,RHOVW(40, 1),FLUXJ( 3,40, 1),IHW,ITW,IFW,ISPW,IRHOVW,IFLUXJ
15. 1 FORMAT(A1)
16. DATA KA/ 6HJ/KG ,6HB/LB , 6HN/M2 ,6HATM , 6HMETER ,6HFOOT
17. 1 , 6HJ/KG=K,6HC/GM=K, 6HDEG=K ,6HDEG=R , 6HJ/KG ,6HC/GM
18. 2 , 6HM/S ,6HF/S , 6HKG/M3 ,6HLB/F3 , 6HMETERS,6H FEET
19. 3 , 6HKG/S ,6HLB/S , 6HW/M2 ,6HB/SF2 , 6HKG/SM2,6HLB/SF2
20. 4 , 6HWATTS ,6H B/S , 6HN-S/M2,6HLB/FS , 6HJ/KG=K,6HB/LB=R
21. 5 , 6HW/M=K ,6HB/SF=R, 6HN/M2 ,6HLBF/F2, 6H (N) ,6H(LBF)
22. 6 , 6H (M2) ,6H (F2) /
23. C CONVERSION FACTORS SI UNITS TO BLIMP UNITS
24. DATA UCD/,062427962/,UCE/4.3021E-04/,UCL/3.28039895/
25. 1 , UCM/2.2046226/,UCP/9.8692327E-06/,UCR/8.8114E-05/
26. 2 , UCS/,020885434/,UCT/1.8/,UCV/,671968995/
27. DATA IAST/1H,/
28. DATA LAST/1H,/
29. DATA IBLANK/2H /
30. KIN=5
31. KOUT=6
32. KPCH=7
33. KPLT=18
34. MSD(1)=KPCH
35. MSD(2)=KPLT
36. JTIME=1
37. B(1)=.5
38. B(2)=.333333333
39. B(3)=.166666666
40. B(4)=.125
41. B(5)=.041666666
42. B(6)=.033333333
43. B(7)=.013888888
44. B(8)=.003968254
45. IT=1
46. MWE=-1
47. NBT=19
48. NBT2=20
49. IS=1
50. IU=1
51. 41 ITEM=1
52. 42 CALL SETUP
53. 43 CALL ITERAT
54. CALL OUTPUT
55. 55 CONTINUE
56. IF(NON)43,44,40
57. 44 ITEM=ITEM+1
58. IF(ITEM=NITEM) 42,42,45
59. 45 ISH=IS
60. IU=IU+1
61. 49 IS=IS+1
62. IF(KQ(10)+IS.EQ.-10)KQ(10)=1
63. IF(IDISC(IS).EQ.2)GO TO 49
64. IF(IS.LE.NS) GO TO 41
65. IF(ITF(11),NE.0) CALL ROCOUT
66. 40 READ(KIN,1) JAST
67. IF(IAS-JAST) 47,46,47
68. 47 IF(LAST-JAST) 40,48,40
69. 48 STOP
70. END

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B03A. SETUP

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1. CB03A
2. SUBROUTINE SETUP
3. DIMENSION HIST1(515),HIST2(716),HIST3(421),VMAT(454),HIST4(520)
4. COMMON/BLGCOM/ MOA( 60), MOB( 60),NSPEC,FR( 60,15),W(31,LEF( 8)
5. 1,LEF9( 8),PIEASE,LEFW( 8)
6. COMMON/EDGCOM/ PE(40, 1),PTE(40, 1),SPE( 6,40, 1),DUES,
7. 1UE(40),RHOE(40),VMUE(40),TE(40),UEDGE,DUEDEGE,D2UEDG,VMWE,WE,C90
8. 2,DSIP(40),IDSIP,TTVC,TVCC(40),HEA(40),SP(20),CS(20),CSPR(20),
9. 3CG(20),CGP(20),SREF,GEP,NEN,UINF,RHOINF,HINF,PINF
10. COMMON/FLPCOM/ LEFT( 8,2)
11. COMMON/HISCOM/C1,C2,C3,C4,ALPHD,BETA,ZH(4,14),ZG(4,14),ZSP(4,14, 6
12. 1),XI(40),HF(15,5),HG(15,3),HSP(15,3, 6),HALPH,HUE,HMHUE,HFW,DLX2
13. 2,C3H(40),BETAM(40)
14. COMMON/INTCOM/ KR(20),KIN,KOUT,MAT1I,MAT2I,MAT1J,MAT2J,NETA,I,IS,N
15. 1S,IT,NTIME,NSP,NSPM1,NAM,NLEQ,NNLEQ,NRNL, ITS,KAPPA,CHAR,CASE(15)
16. 2,B(8), MWE,NQN,KQ(10),ITEM,NITEM,KR17,NRT,NRT2,IDENT,KR9(40)
17. 3,KAUXO,JTIME,JSPEC,MD(3),IU,ISH
18. 4,KONRFT
19. COMMON/PRHCOM/TIME( 50),PRE(40),PTET( 50),GE( 50),S(40),ROKAP(40)
20. 1,RNOSE,VKAP,NDISC,DISC(40),NSD(5),MSD(5),ITF( 50),IPRE,RADNO,CONE
21. 2,RADFL( 50),RADR(40),RADS(40),IRAD
22. COMMON/VARCOM/F(4,15),G(3,15),SP(3,15, 7),ALPH
23. COMMON/WALCOM/FW(40, 1),TW(40, 1),HW(40, 1),SPW( 6,40, 1)
24. 1,RHOVW(40, 1),FLUXJ( 3,40, 1),IHW,ITW,IFW,ISPW,IRHOVW,IFLUXJ
25. COMMON/UNICOM/UCD,UCE,UCL,UCM,UCP,UCR,UCS,UCT,UCV,ITOK
26. 1,IUNIT,IPLOT,KA(2,19)
27. EQUIVALENCE(HIST1,XI),(HIST2, PE),(HIST3,F),(VMAT,C1),(HIST4,FW)
28. 2 FORMAT(1H18X4HTIMEE12,5,56H SECONDS - - - - -)
29. 1 - - - - - ,2X3A6)
30. 3 FORMAT(1H17X4HTIMEE12,5,35H SECONDS - - - STREAMWISE DIMENSTONE12
31. 1,5,11HFEET - - - ,2X3A6)
32. 4 FORMAT(1H18X4HCASE13,32(2H -)2X3A6)
33. 5 FORMAT(1H1,7X,7HSTATION,14,9(2H -),15H AXIAL POSITION ,E12.5,1X,
34. 1 A6 ,6(2H -),3A6)
35. 9001 FORMAT(13,7E10.3)
36. DATA MD(2)/6H /
37. MD(1)=MD(2)
38. MD(3)=MD(2)
39. CALL ETIME
40. CALL DATE(9,MD)
41. CALL TOD(18,MD)
42. KR(2)=2
43. J=MOD(ITEM,2)+1
44. IF (MWE+1) 1154,101,1154
45. 1154 IF (KONRFT=1) 154,154,103
46. C INPUT CONTROL AND TITLE CARD, NUMBER OF ELEMENTAL SPECIES TO BE
47. C CONSIDERED, TIMES AND BODY POSITIONS TO BE CALCULATED, AND
48. C REFERENCE CONDITIONS(WHEN GIVEN AT THESE PRECISE TIMES AND BODY
49. C POSITIONS
50. 101 CALL RECASE
51. KQ(10)=0
52. IF(KR(7).GT.1) CALL TRMBL(1)
53. IS=1
54. IT=1
55. C INPUT ETA VALUES AND SET UP AND INVERT LINEAR MATRICES.NOTE..KR(1)
56. C MUST BE UNITY FOR FIRST CASE, BUT FORMATION OF BA1 AND BA2 CAN BE
57. C AVOIDED FOR SUBSEQUENT CASES BY SETTING KR(1) EQUAL TO ZERO. THIS
58. C CAN BE DONE IF AND ONLY IF ETA SPACING IS THE SAME
59. IF(KR(1)) 104,104,103
60. 103 CALL LINMAT
61. IF (KONRFT.EQ.2) GO TO 154

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B03A. SETUP

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62.      104 KR17=KR(17)
63.      154 IF(I9+ITEM=2) 105,105,1572
64.      1572 IF(KR(3)) 1570,1577,1570
65.      1570 DO 1573 K=1,8
66.          IF(LEF(K)=1) 1573,1575,1573
67.      1575 LEF(K)=2
68.      1573 CONTINUE
69.      1577 IF(KONRFT.NE.2)GO TO 107
70.  C      INITIAL GUESSES FOR PRINCIPAL DEPENDENT VARIABLES. CALCULATE(KR(2)
71.  C      =0), INPUT(KR(2)=1), OR USE VALUES FROM FROM PREVIOUS CASE(KR(2)
72.  C      =2). NOTE..LATTER REQUIRES SAME ETA VALUES AND SAME SPECIES. ITS
73.  C      UTILITY IS FOR REPEATED SIMILARITY SOLUTIONS. IT OBVIOUSLY CANNOT
74.  C      BE USED FOR FIRST CASE.
75.      105 CALL FIRSTG
76.          IF (KONRFT.EQ.2) GO TO 107
77.          IF(TIME(1)) 1051,1052,1052
78.      1051 ITAB=ABS(TIME(ITEM))
79.          WRITE(KOUT,4) ITAB, MD
80.          GO TO 106
81.      1052 WRITE(KOUT,2) TIME(ITEM),MD
82.      106 IF(KR(7))204,204,203
83.      203 IF(KR(12).NE.1) CALL STATEN
84.          GO TO 202
85.      204 IF(KR(12).NE.1) CALL INPUT(PTET(1))
86.      202 CALL REFCN
87.          IF(KG(9).NE.0) CALL TVCEDG
88.          KR(12)=1
89.          IS=1
90.      107 DO 1262 I=1,8
91.          IF(I9.EQ.1.AND.LEF(I).EQ.2.AND.KR(2).GE.0)LEF(I)=1
92.      1262 LEFT(I,J)=LEF(I)
93.  C-----COMPUTE HISTORIC INFORMATION
94.          KR3ST=KR(3)
95.          IF (KONRFT.EQ.2.AND.KR(3).EQ.2) KR(3)=1
96.          CALL HISTXI
97.          KR(3)=KR3ST
98.          IF(TIME(1)) 1053,1054,1054
99.      1053 ITAB=ABS(TIME(ITEM))
100.          WRITE(KOUT,5)IS,PTET(IS+10),KA(IUNIT+1,9),MD
101.          GO TO 126
102.      1054 WRITE(KOUT,3)TIME(ITEM),8(IS),MD
103.      126 CONTINUE
104.          MWE=0
105.  C      START OF ITERATION LOOP
106.      158 ITS=0
107.          KR(17)=KR17
108.      159 RETURN
109.      END

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B04A, ITERATE

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1. CB04A
2. SUBROUTINE ITERAT
3. COMMON/BLQCOM/ MDA( 60), MOB( 60),NSPEC,FR( 60,15),W(3),LEF( 8)
4. 1,LEFS( 8),PIEASE,LEPW( 8)
5. COMMON/BUHCOM/ BUMP,CORMA,EASE,ICORM,WDOT,TFZ,I777,DTEMP,KIP,IX
6. COMMON/ETACOM/ETA(15),DELTA(15),DSQ(14),DCU(14),B1(14),B2(14)
7. 1,LAR(123),BA1(43,18),BA2(30,15)
8. COMMON/ERRCOM/FLE( 43),GLE(30),SPLE(30, 6),ELA(253),FLEM,GLEM
9. 1,SPLEM( 6),ELM(14),ELMM,IFLM,IGLM,ISPLM( 6),NELM,ILMM,DFL(43)
10. 2,DGL(30),DSPL(30, 6),FNLE(18),GNLE(15),SPNLE(15, 6),ENL(123)
11. 3,FNLEM,GNLEM,SPNLEM( 6), ENLMM,IFNLM,IGNLM,ISPMLM( 6)
12. 4,NENLM,INLMM,DFNL(18),DGNL(15),DSPNL(15, 6),DRNL( 8)
13. COMMON/INTCOM/ KR(20),KIN,KOUT,MAT1I,MAT2I,MAT1J,MAT2J,NETA,I,IS,N
14. 18,IT,NTIME,NSP,NSPH1,NAM,NLEQ,NNLEQ,NRNL, ITS,KAPPA,CBAR,CASE(15)
15. 2,B(8), MWE,NON,KQ(10),ITEM,NITEM,KR17,NRT,NRT2,IDENT,KR9(40)
16. 3,KAUXO,JTIME,JSPEC,MD(3)
17. COMMON/PRMCOM/TIME( 50),PRE(40),PTET( 50),GE( 50),S(40),ROKAP(40)
18. 1,RNDSE,VKAP,NDISC,IDISC(40),NSD(5),MSD(5),ITF( 50),TPRE,RADON,CONE
19. 2,RADFL( 50),RADR(40),RAD8(40),IRAD
20. COMMON/VARCOM/F(4,15),G(3,15),SP(3,15, 7),ALPH
21. 5 FORMAT(I3,1X,F8.3,F6.3,F7.4,F6.4,1PE7.0,8(I3,E8.1))
22. 6 FORMAT(/1X15ITERATED VALUES11X47HDAMP MAX,LIN MAX,ERRORS IN CO
23. 1NSERVATION EQS./1X58HITS TIME ALPH FPPW ERROR MOMEN
24. 1TUM ENERGY 6(5XA4,A2))
25. 1 FORMAT(22H NON-CONVERGENT OUTPUT)
26. 181 ITS=ITS+1
27. JTIME=MAX0(JTIME,0)
28. CALL TLEFT(ILEFT)
29. IF(ILEFT-JTIME) 30,30,31
30. JTIME=-JTIME
31. KR(4)=1
32. KR(16)=1
33. KR(18)=1
34. KR(19)=1
35. 31 CONTINUE
36. NON=2
37. 123 IF(ITS=5) 328,328,321
38. 120 IF(KR(2)) 325,321,321
39. 121 IF(KQ(10)+10) 326,322,326
40. 126 IF(NON=2) 325,330,325
41. 125 RETURN
42. 122 KQ(10)=2
43. IDISC(18)=1
44. EASE=0.11
45. ITS=2
46. WRITE(KOUT,324)
47. 124 FORMAT(96H1 PRIOR LAMINAR SOLUTION AFTER TRANSITION. TURBULENCE
48. 1 WILL BE INCLUDED AND SOLUTION CONTINUED //)
49. 128 IF(NON) 325,330,330
50. 130 NON=0
51. IF(ITS.EQ.1) CALL NNNCR
52. CALL NONCR
53. EASY=EASE
54. ITS=ITS+1
55. CALL NNNCR
56. ET=ALPH*ETA(NETA)*0.00004
57. ITS=ITS-1
58. CALL ETIMEF(TMD)
59. FPPW=F(3,1)/(ALPH*ALPH)
60. IF(KQ(10).EQ.2) GO TO 1900
61. IF(KR(4)+KR(16)+KR(17)+KR(18)/2+KR(19)+KR(20)+NON) 189,189,1901

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B04A. ITERAT

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62. 189 IF (ITS-1) 1901,1901,1911
63. 1900 KQ(10)=1
64. 1901 IF (NSPM1) 192,192,190
65. 190 WRITE(KOUT,6)(MOA(K),MOB(K),K=1,NSPM1)
66. GO TO 191
67. 192 WRITE(KOUT,7)
68. GO TO 194
69. 1911 IF (NSPM1)194,194,191
70. 191 WRITE(KOUT,5)ITS,TIMD,ALPH,FPPW,EASY,ELMM,IFNLM,FNLEM,IGNLM,GNLEM,
71. 1(ISPMLM(K),SPNLEM(K),K=1,NSPM1),NON
72. GO TO 1920
73. 194 WRITE(KOUT,5)ITS,TIMD,ALPH,FPPW,EASY,ELMM,IFNLM,FNLEM,IGNLM,GNLEM
74. 1920 IF(KR(2)) 162,1921,1921
75. 1921 IF(ELMM+ENLMM-ET) 162,162,159
76. 7 FORMAT(/7X65HITERATED VALUES DAMP MAX,LIN MAX,ERRORS IN CONSE
77. 1RVATION EQS./1X58HITS TIME ALPH FPPW ERROR MOMENTUM
78. 2 ENERGY )
79. 162 NON=0
80. GO TO 320
81. 159 IF(ITS-50) 161,160,160
82. 160 WRITE(KOUT,1)
83. IF(ELMM+ENLMM-100.0*ET) 162,162,1601
84. 1601 NON=1
85. GO TO 320
86. C ITERATE OR OUTPUT
87. 161 IF(KR(4)) 181,181,193
88. 193 NON=1
89. GO TO 323
90. END

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1.      C      B05B
2.      SUBROUTINE NNNCER
3.      INTEGER ASU,BSU
4.      DIMENSION COEQV(84), COEFQV(249)
5.      COMMON/BLQCOM/ MQA( 60), MOB( 60), NSPEC,FR( 60,15),W(3),LEF( 8)
6.      1,LEFS( 8),PIEASE,LEFW( 8),L2,L3
7.      COMMON/BUMCOM/ BUMP,CORMA,EASE,ICORM,WDOT,TFZ,I777,DTEMP,KIP,IX
8.      COMMON/COECON/ C5,C6,C7,C8,C9,C10,C11,C12,C13,C14,C15
9.      1,C16,C17,C18,C19,C20,C21,C22,C23,C24,C25,C26,C27,C28,C29,C30,C31,C
10.     232,C33,C34,C35,C36,C37,C38,C39,C40,C41,C42,C43,C44,C45,C46,C47,C48
11.     3,C49,C50,C51,C52,C53,C54,C55,C56,C57,C58,C59,C60,C61,C62,C63,C64,C
12.     465,C66,C67,C68,C69,C70,C71,C72,C73,C74,C75,C76,C77,C78,C79,C80,C81
13.     5,C82,C83,C84,C85,C86,C87,C88
14.     COMMON/COECON/ CK1( 6),CK2( 6),CK3( 6),CK4( 6),CK5( 6),CK6( 6)
15.     1,CK7( 6),CK8( 6),CK9( 6),CK10( 6),CK11( 6),CK12( 6),CK13( 6)
16.     2,CK14( 6),CK15( 6),CK16( 6),CK17( 6),CK18( 6),CK19( 6),CK20( 6)
17.     3,CK21( 6),CK22( 6),CKK1( 6, 6),CKK2( 6, 6),XM(5),XG(5),XSP(5, 7)
18.     4,CKK3( 6, 6)
19.     COMMON/CRBCOM/HCARB,EMIS,STEF,ADUM,BDUM,CDUM,WTEF,HMAT,EMISC,FMIST
20.     1,HPG,ASU(3),BSU(3),HPYG(3),HCHAR(3),EMIV(3),KS(40),ISU
21.     COMMON/EDGCOM/ PE(40, 1),PTE(40, 1),SPE( 6,40, 1),DUES,
22.     1UE(40),RHOE(40),VMUE(40),TE(40),UEDGE,DUEDGE,D2UEDG,VMWE,CGE,C90
23.     2,DSIP(40),IDSIP,TTVC,TVCC(40),HEA(40),SF(20),CS(20),CSPR(20),
24.     3 CG(20),CGP(20),SREF,GEP,NEN,UINF,RHOINF
25.     COMMON/EPSCOM/ELCON,YAP,CLNUM,SC1,PRT,RED,DVS,RHOVS,PI,PIM,CL,
26.     1 EPSA(15),EPS1,EL(15),DPI(15,2),DEPC,TREF,RETR
27.     COMMON/EGPCOM/RB(60,3),RC(60,3),RD(60,3),RE(60,3),RF(60,3),RG(60,3)
28.     1),TU(60,3),FF(60),FFA,IFC(60),ATA(8),ATB(8),ATC(8),WAT(8),RA(60,3)
29.     5,
30.     2 KAT( 8),IR( 8),IZ,KZ(10),LAMI( 60),P,Z,TK( 8, 8),VNC( 60),
31.     3 VNU( 60, 8),ITFF,KR2,HCH,NCV,WM,WTM( 60),YYY( 60),YW( 60),GG( 60)
32.     4 ,TQ( 8, 8),EPOVRK,SIGMA,BASMOI
33.     COMMON/EQTCOM/SIP,HIP,EEL,EENL,FLIQ,CPF,IRE,IER,AA,IITS,IN,IL,IIT,
34.     1 MODE,HMELT,SMELT,TMAX,TMIN,MELT,SUMN,SUML,WS,WSS,BX,ISP2,ISPO,
35.     2 ISP,KKJ,SVA,SVB,SVC,SVD,SUMC,FFF,CMF,EP,RV,IFCJC,WTG,WTL,JC,HMG,
36.     3 CCPG,TTMIN,TTMAX,L7,L8,IB( 9),EB( 8),EBL( 8),A(14,14),RB(14),
37.     4 IP( 60),ALP( 8),FNU( 8),GAMH( 8),GAMF( 8),SLAM( 8),DY( 60),PVS,
38.     5 CP( 60),HH( 60),SB( 60),TC( 60),VLNK( 60),E( 60),PNUS( 8),
39.     6 BC( 8),BLNK( 8),BY( 60),IBC( 8),BE( 8),JZ( 4)
40.     COMMON/ERRCOM/FLE( 43),GLE(30),SPLE(30, 6),ELA(253),FLEM,GLEM
41.     1,SPLEM( 6),ELM(14),ELMM,IFLM,IGLM,ISPLM( 6),NELM,ILMM,DFL(43)
42.     2,DGL(30),DSPL(30, 6),FNLE(18),GNLE(15),SPNLE(15, 6),ENL(123)
43.     3,FNLEM,GNLEM,SPNLEM( 6), ENLMM,IFNLM,IGNLM,ISPNLM( 6)
44.     4,NENLM,INLMM,DFNL(18),DGNL(15),DSPNL(15, 6),DRNL( 8)
45.     COMMON/ETACOM/ETA(15),DETA(15),DSQ(14),DCU(14),B1(14),B2(14)
46.     1,LAR(123),BA1(43,18),BA2(30,15)
47.     COMMON/FLXCOM/DELQW,DELJW( 6),WALLQ,WALLJ( 6),QW,VJKW( 7),TPWALL
48.     COMMON/HISCOM/C1,C2,C3,C4,ALPHD,BETA,ZM(4,14),ZG(4,14),ZSP(4,14, 6
49.     1),XI(40),HF(15,5),HG(15,3),HSP(15,3, 6),HALPH,HUE,HWF,HFW,DLX2
50.     2,C3M(40),BETAM(40)
51.     COMMON/INTCOM/ KR(20),KIN,KOUT,MAT1I,MAT2I,MAT1J,MAT2J,NETA,I,IS,N
52.     18,IT,NTIME,NSP,NSPM1,NAM,NLEQ,NNLEQ,NRNL, ITS,KAPPA,CBAR,CASE(15)
53.     2,B(8), MWE,NON,KQ(10),ITEM,NITEM,KR17,NBT,NBT2,IDENT,KR9(40)
54.     3,KAUXO,JTIME,JSPEC,MD(3),IU,ISH
55.     COMMON/NONCOM/AM(123,123),DVNL(123),TCW,
56.     1VLNKW,DLPH( 7),DLPK( 6, 7),DTHW,DTKW( 6),FLUXJB( 7)
57.     COMMON/PRMCOM/TIME(50),PRE(40),PTET(50),GE(50),S(40),ROKAP(40)
58.     COMMON/PRPCOM/PR(15),T(15),RHO(15),SC(15),CAPC(15),QR(15),H(15)
59.     1,CPBAR(15),VMW(15),PHK(15, 6),DRHOK,DRHOK( 6),ZK( 6),DZKH( 6), D
60.     2MU3K( 6),DMU4K( 6),DTK( 6),DPHKH( 6),DPRK( 6),DSCK( 6),DCAPCK( 6)
61.     3,DHTILK( 6),DQRK( 6),DCPBK( 6),DCPTK( 6),DMU12K( 6),DZKK( 6, 6)

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62. 4,DPHIKK( 6, 6),          DMU4H,DMU3H,DHTILH,VMU12,CT,CTR,CPTIL,HTIL
63. 5,VMU3,DTH,DCAPCH,DPRH,DSCH,DGRH,DCPBH,DCPTH,DMU12H,VMU(15),  RHOP
64. 6(15),PHIKP(15),HP,TP,ZKP( 6),VMU3P,VMU4P,HTILP,CRHO(14),GMR(15)
65. COMMON/VARCOM/F(4,15),G(3,15),SP(3,15, 7),ALPH
66. COMMON/WALCOM/FW(40, 1),TW(40, 1),HW(40, 1),SPW( 6,40, 1)
67. 1,RHOVW(40, 1),FLUXJ( 3,40, 1),IHW,ITW,IFW,ISPW,IRHOVW,IFLUXJ
68. DIMENSION ENLM(1),IENLM(1)
69. COMMON/TURB/          STURB
70. EQUIVALENCE (ENLM(1),FNLEM),(IENLM(1),IFNLM)
71. DIMENSION DELQJW(1),WALLQJ(1)
72. EQUIVALENCE(DELQW,DELQJW(1)),(WALLQ,WALLQJ(1))
73. DIMENSION EQT(1)
74. EQUIVALENCE(EQT(1),SIP)
75. DIMENSIONCORAR(1)
76. EQUIVALENCE(CORAR(1),AM(1))
77. DIMENSION PREQ(1)
78. DIMENSION ZEIT(9)
79. EQUIVALENCE(PREQ(1),DRHOW)
80. EQUIVALENCE(C5,COEQV),(CK1(1),COEFQV)
81. C**NB***NOTE 240+1,540+1,725,730+1 WHEN REDIMENSIONING
82. EASE=AMINI(EASE*2.,1.0)
83. IF(ITS-1) 11,5,11
84. 5 EASE = .3333
85. BUMP = 1.0
86. IF(ITEM+IU-2)3,3,2
87. 2 IF(WDOT) 4,3,3
88. 3 WDOT=-.12/C1
89. 4 PIEASE=1.
90. ICORM = 1
91. CORMA = 1.E + 10
92. TFZ = 0.
93. IF (KR9(18)) 8,8,7
94. 7 KR(9)=KR9(18)
95. 8 DO 17 I=1,NETA
96. 17 EPSA(I)=0.
97. IF(KR(9)-2) 11,10,9
98. 9 FLUXJ(3,IS,IT)=-1.
99. 10 ISU=IZ+1
100. KK=MAX0(1,KS(18))
101. W(1) = FLUXJ(1,IS, IT)
102. W(2)=FLUXJ(2,IS,IT)
103. W(3)=FLUXJ(3,IS,IT)
104. L2=2*KK
105. L3=L2+1
106. IF(KR(9)-2) 11,11,16
107. 16 HPG=HPYG(KK)
108. EMISC=EMIV(KK)
109. HCARB=HCHAR(KK)
110. DO 12 J=ISP,NSPEC
111. IF(MOA(J)-ASU(KK)) 12,13,12
112. 13 IF(MOB(J)-BSU(KK)) 12,14,12
113. 14 ISU=J
114. GO TO 11
115. 12 CONTINUE
116. ISU=ISP
117. 11 KIP=0
118. IX = 0
119. C--- EVALUATE COEFFICIENTS AND ERRORS FOR NONLINEAR EQUATIONS
120. C INITIALIZE AM MATRIX
121. DO 15 I=1,123
122. ENL(I)=0.
123. DO 15 J=1,NNLEQ
124. 15 AM(I,J) = 0.
125. C EVAL. GROUPINGS WHICH CHANGE DURING ITERATION BUT ARE NOT F(ETA)

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124.      40 C5 = 1. / ALPH
127.      DUM1 = ALPH * ALPH
128.      C6 = BETA * DUM1
129.      CONJ=25036.5
130.      C7=-UE(IS)/DUM1*UE(IS)/CONJ
131.      C8 = ALPHD * C5
132.      C9 = C4 - C8
133.      C      FINALLY, EVAL CONTRIBUTIONS TO AM AND ERRORS FROM OTHER COEFFS
134.      C----- START OF MAJOR DO LOOP FOR EVAL OF COEFFS AND ERRORS AT EACH ETA
135.      KQ(1)=2
136.      KQ(5)=0
137.      CALL ETIMEF(ZEIT(1))
138.      DO 49 I=1,NETA
139.      M=MAT1J+I-MAT2J
140.      MX=MAT2J-1
141.      H(I)=G(1,I)+0.5*F(2,I)*C7*F(2,I)
142.      HP=G(2,I)+F(2,I)*C7*F(3,I)
143.      IF(KR(7)) 47,47,46
144.      46 CALL STATE
145.      GO TO 48
146.      47 CALL EQUIL(KQ,H(I),PE(IS,IT))
147.      48 IF(I=1) 50,50,54
148.      50 IF(NSPM1) 53,53,51
149.      51 DO 52 K=1,NSPM1
150.      DO 31 KK=1,I2
151.      31 DLPH(K,KK) = A(KK+2, K+2)
152.      52 DTKW(K)= DTK(K)
153.      DO 32 KK=1,I2
154.      32 DLPH(KK)= A(KK+2,1)
155.      VLNKW=VLNK(ISU)
156.      TCW=TC(ISU)
157.      HCHAL = HH(ISU)/WTM(ISU)*1.8
158.      53 DTHW=DTH
159.      M=116
160.      MX=1
161.      54 RHOP(I)=DRHOM*HP
162.      IF(NSPM1) 58,58,56
163.      56 DO 57 K=1,NSPM1
164.      57 RHOP(I)=RHOP(I)+DRHOK(K)*SP(2,I,K)
165.      58 L=0
166.      C-----UPPER LIMIT IS MAX NUMBER OF SPECIES (MXNSP) =LAST DIM ON SP
167.      DO 49 MM=1, 7
168.      M=M+MX
169.      C-----UPPER LIMIT CORRESPONDS TO DIMENSIONS ON AM ARRAY
170.      C-----LOWER LIMIT IS UPPER LIMIT-(2*MXNSP+11+4/MXNSP)
171.      DO 49 N=98,123
172.      L=L+1
173.      49 AM(M,N)=PREQ(L)
174.      RETURN
175.      ENTRY NONCER
176.      CONJ=25036.5
177.      UEDGE=1.
178.      DUEGE=0.
179.      GEP=0.
180.      CGE=0.
181.      CGEP=0.
182.      DUM=-RHOE(IS)*ROKAP(IS)*C3*VMUE(IS)
183.      SFE=DUM*F(1,NETA)*UE(IS)
184.      IF(KR(5)=2) 486,487,486
185.      487 IF(XI(IS)) 488,489,488
186.      489 FEDGE=-RHOINF/2.*UINF/(RHOE(IS)*C3*VMUE(IS)*DUES)
187.      GO TO 497
188.      488 FEDGE=RHOINF/DUM*UINF/UE(IS)*(ROKAP(IS))*2/2.
189.      497 SFE=FEDGE+DUM*UE(IS)

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190. 486 IF(KR(5)=4) 490,496,499
191. 490 IF(KR(5)=2) 499,491,491
192. 496 CALL OGLE (1,SFE,CGE,CSEP,NEN,SF,CG,CGP)
193. 491 CALL OGLE (1,SFE,CSE,CSEP,NEN,SF,CS,CSPR)
194. DUB=CSE+SREF-SIP
195. CHE=1.8*HIP+T(NETA)*DUB*(1.+0.5*DTH*DUB)-HEA(13)
196. CTE=T(NETA)*(1.+DTH*DUB)
197. CHEP=CTE*CSEP
198. IF (XI(13)) 492,492,495
199. 492 IF(KR(6)=1) 493,494,494
200. 493 DUEGE=-RHOE(13)/DUES*(CGEP-CHEP)*C3*VMUE(13)*CONJ
201. UEDGE=SQRT(1.+2.*DUEGE*F(1,NETA))
202. GEP=0.
203. GO TO 499
204. 494 GPP=(CGP(2)-CGP(1)+CTE*(CSPR(2)-CSPR(1)))/(SF(2)-SF(1))
205. DUEGE=GPP*DUM*DUM*F(1,NETA)*CONJ
206. UEDGE=SQRT(1.+DUEGE*F(1,NETA))
207. GEP=0.
208. GO TO 499
209. 495 UEDGE=SQRT(1.+2.*CONJ/UE(13)*(CGE-CHE)/UE(13))
210. GEP=DUM*UE(13)*CGEP*UEGE
211. DUEGE=DUM/UE(13)*(CGEP-CHEP)*CONJ
212. 499 DUF=DUEGE/UEGE
213. CGE=CGE+GE(ITEM)
214. CALL LINCER
215. CALL ETIMEF(ZEIT(2))
216. IF(KQ(10).GT.0) CALL TRMBL(2)
217. CALL ETIMEF(ZEIT(3))
218. TTVC=1.0
219. M=116
220. MX=1
221. DO 120 I=1,NETA
222. L=0
223. C-----UPPER LIMIT IS MAX NUMBER OF SPECIES (MXNSP) LAST DIM ON SP
224. DO 59 MM=1, 7
225. M=M+MX
226. C-----UPPER LIMIT CORRESPONDS TO DIMENSIONS ON AM ARRAY
227. C-----LOWER LIMIT IS UPPER LIMIT - (2*MXNSP+11+4/MXNSP)
228. DO 59 N= 98,123
229. L=L+1
230. PREQ(L)=AM(M,N)
231. 59 AM(M,N)=0.
232. C TEST TO BYPASS COMMANDS THAT CANNOT BE PERFORMED AT ETA(1)
233. IF (I = 1) 60,60,55
234. 55 CALL IMONE
235. IF(KQ(9).NE.0) CALL TVCM1
236. IF(KQ(10).GT.0) CALL TRMBL(4)
237. C COMPUTE STATIC ENTHALPY AND DETERMINE STATE OF GAS
238. 60 C10 = C7 * F(2,I)
239. C13 = C7 * F(3,I)
240. HP = G(2,I) + F(2,I) * C13
241. C----- EVAL GROUPINGS WHICH ARE USED AT I=1 AS WELL AS AT I
242. 75 CALL ICoeff
243. IF(KQ(9).NE.0) CALL TVCCOE
244. IF(KQ(10).GT.0) CALL TRMBL(3)
245. IF (I = 1) 100,80,100
246. C DLPK,TCW,VLNKW,OLPH, AND Y1 NEEDED ONLY FOR CARBON PROBLEM
247. 80 IF (NSPM1) 95,95,85
248. 85 DO 90 K=1,NSPM1
249. WALLJ(K) = CK6(K)
250. VJKW(K) = CK6(K) / C3
251. 90 CONTINUE
252. 95 WALL0 = C32
253. OW = C32 / C3

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254.      TPWALL = TP
255.      MX=MAT2J-1
256.      GOTO 105
257. C--- BACK TO CONSERVATION EQUATIONS
258.      100 CALL IONLY
259.          IF(KG(10).GT.0) CALL TRMBL(5)
260.          IF(KG(9).NE.0) CALL TVCI
261.      105 IF (KR(17)) 120,120,115
262.      110 FORMAT(21H ALL THE COEFFICIENTS/(1X1P12E10.3))
263.      115 WRITE(KOUT,110)C1,C2,C3,C4,COEEGV,COEFGV
264.          IX = - 2
265.      120 M=MAT1J+I-MX
266.          DO 122 I=2,4
267.          DO 122 J=1,NNLEQ
268.      122 AM(I,J)=0.
269.          ENL(4)=-(ALPH*UEDGE-F(2,NETA))
270.          AM(4,1)=UEDGE
271.          AM(4,MAT1J)=-1.
272.          CALL LIAD(-1,4,NETA-1,ALPH*DUP)
273.          ENL(3)=-F(2,1)
274.          AM(3,4)=1.
275.          IF(KR(5)=2) 123,121,123
276.      121 ENL(2)=F(1,NETA)-FEDGE*TTVC
277.          CALL LIAD(-1,2,NETA-1,-1.)
278.          GO TO 124
279.      123 ENL(2)=CBAR*(F(2,NETA)-(ETA(NETA)-ETA(KAPPA))*F(3,NETA))-F(2,KAPPA
280.          1)
281.          IF(KR(5).EQ.0) ENL(2)=CBAR*F(2,NETA)-F(2,KAPPA)
282.          AM(2,KAPPA+3)=1.
283.          AM(2,MAT1J)=-CBAR
284.          IF(KR(5).GT.1)CALL LIAD(-1,2,NETA+NETA-2,CBAR*(ETA(NETA)-ETA(KAPPA
285.          1)))
286.      124 CALL ETIMEF(ZEIT(4))
287.          IF (ITS = 1) 125,125,145
288.      125 DO 140 K=1,NBP
289.          IF (LEFS(K)) 130,130,140
290.      130 IF(LEF(K)) 140,140,135
291.      135 EASE = .05
292.      140 CONTINUE
293.      145 IF(KR(19)) 170,190,170
294.      170 CONTINUE
295.          WRITE(KOUT,175)
296.      175 FORMAT(2X21HDEBUG FNLE,GNLE,SPNLE)
297.      180 FORMAT(/2X1P11E10.3/(12X1P10E10.3))
298.          WRITE (KOUT,180) (ENL(I),I=1,NNLEQ)
299. C      SEEK MAXIMUM ERROR FOR EACH CONSERVED QUANTITY
300.      190 M=2
301.          MM=MAT1J-1
302.          DO 200 I=1,NNRL
303.          CALL ABMAX(MM=1,ENL(M),ENLM(I),IENLM(I))
304.          IENLM(I) = IENLM(I)+1
305.          M=M+MM
306.      200 MM=MAT2J-1
307. C      SOLVE REDUCED SET OF EQUATIONS
308.          IF (KR(2).LT.0) RETURN
309. C      SCRUNCH DEFINED ROWS OF AM MATRIX TO THE TOP
310.          DO 240 M=1,NAM
311.          ENL(M)=ENL(M+1)
312.          DO 240 J=1,NNLEQ
313.      240 AM(M,J)=AM(M+1,J)
314.          IF(KG(10).LE.0) GO TO 1001
315.          DO 1000 M=4,NAM
316.      1000 AM(M,3)=AM(M,3)+ENL(M)/F(3,1)
317.      1001 CONTINUE

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318. C THE FOLLOWING ROUTINE REARRANGES COLUMNS OF THE NOW RECTANGULAR
319. C AM MATRIX, ACCORDING TO LAR, INVERTS ((AM(I,J), J=2,NAM), I=1,NAM) AND
320. C MULTIPLIES THE INVERSE TIMES THE REMAINING COLUMNS OF AM MATRIX
321. C AND TIMES THE ENL.
322. CALL ETIMEF(ZEIT(5))
323. CALL RERAY(NAM,AM,NSP+1,ENL,1,LAR,IX,123,EQT,EQT(124),EQT(247),
324. 1 EQT(370),EQT(493))
325. CALL ETIMEF(ZEIT(6))
326. 244 IF(KR(17)) 245,265,245
327. 245 CONTINUE
328. 250 FORMAT(2X1P11E10.3)
329. WRITE(KOUT,255)
330. 255 FORMAT(2X18HDEBUG FILE,GLE,SPLE)
331. WRITE(KOUT,250)FLE,GLE
332. IF (NSPM1) 265,265,260
333. 260 WRITE(KOUT,250)((SPLE(I,K),K=1,NSPM1),I=1,MAT2I)
334. C*****SURFACE OPTIONS TREATED IN RNLCE WITH REDUCED NONLINEAR SET
335. 265 CALL ETIMEF(ZEIT(7))
336. CALL RNLCE
337. CALL ETIMEF(ZEIT(8))
338. C DETERMINE MAXIMUM NONLINEAR ERRORS
339. C EQUIVALENCE ENLM TO FNLEM, GNLEM, AND SPNLEM
340. 595 DO 605 I=1,NRNL
341. IF(ABS(ENLM(I))-ABS(DRNL(I))) 600,605,605
342. 600 ENLM(I) = DRNL(I)
343. ENLM(I) = 1
344. 605 CONTINUE
345. VNORM=AMAX1(0.1,ABS(BETA))*ALPH
346. ENORM=AMAX1(1000., ABS(G(1,NETA)-G(1,1)))
347. ENLM(1) = ENLM(1)/VNORM
348. ENLM(2) = ENLM(2)/ENORM
349. CALL ABMAX(NRNL,ENLM,ENLMM,INLMM)
350. ENLMM = ENLMM/10.
351. ENLM(1) = ENLM(1)*VNORM
352. ENLM(2) = ENLM(2)*ENORM
353. ELMM = ABS(ENLMM)
354. BIP = KIP
355. ENLMM = ABS(ENLMM) + 3. * BIP
356. C EVALUATE NONLINEAR CORRECTIONS FROM THE REDUCED SET
357. DO 615 I=1,NAM
358. L = LAR(I)
359. DVNL(L) = ENL(I)
360. DO 615 K=1,NRNL
361. J = K + NAM
362. 615 DVNL(L) = DVNL(L) - DRNL(K) * AM(I,J)
363. DO 620 K=1,NRNL
364. I = NAM + K
365. J = LAR(I)
366. 620 DVNL(J) = DRNL(K)
367. C-----RECYCLE IF ALPH WANTS TO GO NEGATIVE
368. IF(DVNL(1)+0.9*ALPH) 626,626,629
369. 626 NUL=0
370. DO 627 K=NUL,NSPM1
371. WALLJ(K)=VJKW(K)*C3
372. 627 ENL(K+117)=0.
373. LIM=NAM+1
374. DO 628 I=2,NNLEQ
375. DUM=AM(I,1)/AM(1,1)
376. ENL(I)=ENL(I)-ENL(1)*DUM
377. DO 628 J=LIM,NNLEQ
378. 628 AM(I,J)=AM(I,J)-DUM*AM(1,J)
379. ENL(1)=0.
380. DO 631 J=LIM,NNLEQ
381. 631 AM(1,J)=0.

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382.     ITS=ITS+1
383.     EASE = AMIN1(EASE,0.2)
384.     IF(ITS-51) 244,244,850
385. 629 CONTINUE
386. C-----EVALUATE LINEAR CORRECTIONS
387.     DO 630 I=1,MAT1I
388.     DO 630 J=1,MAT1J
389. 630 FLE(I) = FLE(I) - DVNL(J) * BA1(I,J)
390.     JJ = MAT1J
391.     DO 635 J=1,MAT2J
392.     JJ = JJ + 1
393.     DO 635 I=1,MAT2I
394. 635 GLE(I) = GLE(I) - DVNL(JJ) * BA2(I,J)
395.     CORAR(1)=DVNL(1)/ALPH*0.5
396.     L=NETA
397.     J=MAT1J+2
398.     DO 640 I=2,NETA
399.     CORAR(I)=DVNL(J)/AMAX1(10000.,G(1,NETA))
400. 640 J=J+1
401.     IF (NSPM1) 665,665,645
402. 645 DO 660 K=1,NSPM1
403.     DO 650 J=1,MAT2J
404.     JJ = JJ + 1
405.     DO 650 I=1,MAT2I
406. 650 SPLE(I,K) = SPLE(I,K) - DVNL(JJ) * BA2(I,J)
407.     J=MAT1J+K+MAT2J+2
408.     DO 655 I=2,NETA
409.     L = L + 1
410.     CORAR(L)=DVNL(J)
411. 655 J=J+1
412. 660 CONTINUE
413. 665 CONTINUE
414.     IF(EASE=0.2) 673,670,670
415. 670 IF(0.33+CORAR(ICORM)/CORMA) 671,675,675
416. 671 BUMP=BUMP+2.0
417.     GO TO 675
418. 673 IF(ABS(1.0-CORAR(ICORM)/CORMA)=0.25) 674,674,675
419. 674 BUMP=BUMP/2.
420. 675 CALL ABMAX(L,CORAR,CORMA,ICORM)
421.     IF (KR(17)) 680,680,685
422. 680 IF (KR(19)) 690,705,690
423. 685 CONTINUE
424.     KR(17) = KR(17) - 1
425. 690 CONTINUE
426. 695 FORMAT(2X38HDEBUG CORRECTIONS RNL,NL,FL AND GL,SPL)
427.     CALL ETIMEF(ZEIT(9))
428.     WRITE(KOUT,696) ZEIT
429. 696 FORMAT(5X33HTIMES BEFOR AND AFTER . . . . .:/6X 9HCHEMISTRY9X
430. 1 13HERRORS+MATRIX9X9HINVERSION12X6HNRNLCER11X3HNDW/10F10.4)
431.     WRITE(KOUT,695)
432.     WRITE(KOUT,250)DRNL
433.     WRITE(KOUT,250)DVNL
434.     WRITE(KOUT,250)FLE,GLE
435.     IF (NSPM1) 705,705,700
436. 700 WRITE(KOUT,250)((SPLE(I,K),K=1,NSPM1),I=1,MAT2I)
437. 705 CONTINUE
438. C CORRECT PRIMARY VARIABLES
439.     DUM = .05 / BUMP
440.     EASE=AMIN1(1.5+EASE,1.0,DUM/ABS(CORMA))
441.     IF(ITS.EQ.2) BUMP=AMAX1(BUMP,.02/ABS(CORMA))
442.     IF(KQ(10).GT.0) EASE=AMIN1(EASE,ABS(F(3,1)/(DVNL(3)+1.E-30)+0.5))
443. 710 IF (KR(13)) 720,720,715
444. 715 DUM = KR(13)
445.     EASE = AMIN1(DUM / 10.,EASE)

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446. 720 IF (EASE = 1.0) 725,740,740
447. 725 DO 730 I=1,253
448. 730 FLE(I) = FLE(I) * EASE
449. DO 735 I=1,123
450. 735 DVNL(I) = DVNL(I) * EASE
451. 740 CONTINUE
452. PIEASE = PIEASE * (1. - EASE)
453. IF (TFZ) 745,750,750
454. 745 TFZ = EASE * DTEMP - TFZ
455. 750 NUL=0
456. DFWE=F(1,NETA)-F(1,1)-XM(5)/F(2,NETA)
457. DO 790 I=1,NETA
458. NI=NETA+I
459. N2I=NETA+NI-2
460. F(2,I)=F(2,I)+DVNL(I+3)
461. F(4,I)=F(4,I)+FLE(N2I)
462. IF(I=1) 760,760,765
463. 760 F(1,1)=F(1,1) + DVNL(2)
464. F(3,1)=F(3,1)+DVNL(3)
465. GO TO 770
466. 765 F(1,I)= F(1,I)+FLE(I-1)
467. F(3,I)=F(3,I)+FLE(NI-2)
468. 770 LPI=MAT1J+I+1
469. DO 785 K=NUL,NSPM1
470. IF(I=NETA) 772,771,772
471. 771 SP(1,I,K)=SP(1,I,K)+SPLE(1,K)
472. GO TO 773
473. 772 SP(1,I,K)=SP(1,I,K)+DVNL(LPI)
474. 773 SP(3,I,K)=SP(3,I,K)+SPLE(NI,K)
475. IF(I=1) 775,775,780
476. 775 SP(2,1,K)= SP(2,1,K) + DVNL(LPI-1)
477. GO TO 785
478. 780 SP(2,I,K)=SP(2,I,K)+SPLE(I,K)
479. 785 LPI=LPI+MAT2J
480. 790 CONTINUE
481. ALPH=ALPH+DVNL(1)
482. IF(KR(19).GT.0)WRITE(KOUT,250)(F(2,J),J=1,NETA),(G(1,J),J=1,NETA),
483. 1 ((SP(1,J,K),J=1,NETA),K=1,NSPM1),ALPH
484. IF (ITS = 49) 850,840,850
485. 840 IF (I777 = 777) 845,850,845
486. 845 I777 = 777
487. ITS = 30
488. 850 CONTINUE
489. IF(KQ(10).GT.-1) RETURN
490. IF(KQ(10).LT.-10) RETURN
491. RETHMO=-C3*VMUE(1S)/VMU(NETA)*RHOE(1S)*UE(1S)*DFWE
492. IF(RETHMO.GT.RETR) KQ(10)=-10
493. IF (RETHMO.GT.RETR) STURB = S(1S)
494. IF(RETHMO.LT.RETR) KQ(10)=1
495. RETURN
496. END

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BOSC, RNLGER

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1.  C      BOSC
2.  SUBROUTINE RNLGER
3.  DIMENSION DOJRN(123,1),WALLQJ(1)
4.  COMMON/BLQCOM/  MDA( 60),  MOB( 60),NSPEC,FR( 60,15),W(3),LEF( 8)
5.  1 ,LEFS( 8),PIEASE,LEFW( 8),L2,L3
6.  COMMON/BUMCOM/  BUMP,CORMA,EASE,ICORM,WDOT,TFZ,I777,DTFMP,KIP,IX
7.  COMMON/COECON/  C5,C6,C7,C8,C9,C10,C11,C12,C13,C14,C15
8.  1,C16,C17,C18,C19,C20,C21,C22,C23,C24,C25,C26,C27,C28,C29,C30,C31,C
9.  232,C33,C34,C35,C36,C37,C38,C39,C40,C41,C42,C43,C44,C45,C46,C47,C48
10. 3,C49,C50,C51,C52,C53,C54,C55,C56,C57,C58,C59,C60,C61,C62,C63,C64,C
11. 465,C66,C67,C68,C69,C70,C71,C72,C73,C74,C75,C76,C77,C78,C79,C80,C81
12. 5,C82,C83,C84,C85,C86,C87,C88
13.  COMMON/COECON/ CK1( 6),CK2( 6),CK3( 6),CK4( 6),CK5( 6),CK6( 6)
14. 1,CK7( 6),CK8( 6),CK9( 6),CK10( 6),CK11( 6),CK12( 6),CK13( 6)
15. 2,CK14( 6),CK15( 6),CK16( 6),CK17( 6),CK18( 6),CK19( 6),CK20( 6)
16. 3,CK21( 6),CK22( 6),CKK1( 6, 6),CKK2( 6, 6),XK(5),XG(5),XSP(5, 7)
17. 4,CKK3( 6, 6)
18.  COMMON/CRBCOM/HCARB,EMIS,STEF,ADUM,BDUM,CDUM,HTEF,HMAT,EMISC,EMIST
19. 1,HPG,ASU(3),BSU(3),HPYG(3),HCHAR(3),EMIV(3),KS(40),ISU
20.  COMMON/EDGCOM/  PE(40, 1),PTE(40, 1),SPE( 6,40, 1),DUES,
21. 1UE(40),RHOE(40),VMUE(40),YE(40),UEDGE,DUEDGE,D2UEDG,VMWE,CGE,C90
22. 2,DSIP(40),IDSIP,TTVC,TVCC(40),HEA(40),SF(20),CS(20),CSPR(20),
23. 3 CG(20),CGP(20),SREF,GEP,NEN
24.  COMMON/EPSCOM/ELCON,YAP,CLNUM,SCT,PRT,RED,DVS,RHOVS,PI,PTM,CL,
25. 1 EPSA(15),EPS1,EL(15),DPI(15,2),DEPC,TREF,RETR
26.  COMMON/EQPCOM/RB(60,3),RC(60,3),RD(60,3),RE(60,3),RF(60,3),RG(60,3
27. 1),TU(60,3),FF(60),FFA,IFC(60),ATA(8),ATH(8),ATC(8),WAT(8),RA(60,3)
28. 5,
29. 2 KAT( 8),IR( 8),IZ,KZ(10),LAMI( 60),P,Z,TK( 8, 8),VN( 60),
30. 3 VNU( 60, 8),ITFF,KR2,HCH,NCV,WM,WTH( 60),YYY( 60),YW( 60),GG( 60)
31. 4 ,TO( 8, 8),EPOVRK,SIGMA,BASMOL
32.  COMMON/EQTCOM/SIP,HIP,EEL,ENL,FLIQ,CPF,IRE,IER,AA,IITS,TN,IL,IIT,
33. 1 MODE,HMELT,SMELT,TMAX,TMIN,MELT,SUMN,SUML,WS,WSS,BX,ISP2,ISPO,
34. 2 ISP,KKJ,SVA,SVB,SVC,SVD,SUMC,FFF,CMF,EP,RV,TFCJC,WTG,WTL,JC,HHG,
35. 3 CCPG,TTMIN,TTMAX,L7,L8,TB( 9),EB( 8),EBL( 8),A(14,14),RB(14),
36. 4 IP( 60),ALP( 8),FNU( 8),GAMH( 8),GAMF( 8),SLAM( 8),DY( 60),RVS,
37. 5 CP( 60),HH( 60),SB( 60),TC( 60),VLNK( 60),E( 60),PNUS( 8),
38. 6 BC( 8),BLNK( 8),BY( 8),IBC( 8),BE( 8),JZ( 4)
39.  COMMON/ERRCOM/FLE( 43),GLE(30),SPLE(30, 6),ELA(253),FLEM,GLEM
40. 1,SPLEM( 6),ELM(14),ELMM,IFLM,IGLM,ISPLM( 6),NELM,ILMM,DFL(43)
41. 2,DGL(30),DSPL(30, 6),FNLE(18),GNLE(15),SPNLE(15, 6),ENL(123)
42. 3,FNLEM,GNLEM,SPNLEM( 6), ENLMM,IFNLM,IGNLM,ISPNLM( 6)
43. 4,NENLM,INLMM,DFNL(18),DGNL(15),DSPNL(15, 6),DRNL( 8)
44.  COMMON/ETACOM/ETA(15),DETA(15),DSQ(14),DCU(14),R1(14),R2(14)
45. 1,LAR(123),BA1(43,18),BA2(30,15)
46.  COMMON/FLXCOM/DELQW,DELJW( 6),WALLQ,WALLJ( 6),QW,VJKW( 7),TPWALL
47.  COMMON/HISCOM/C1,C2,C3,C4,ALPHD,BETA,ZH(4,14),ZG(4,14),ZSP(4,14, 6
48. 1 ),XI(40),HF(15,5),HG(15,3),HSP(15,3, 6),HALPH,HUE,HMUE,HFW,DLX2
49. 2,C3H(40),BETAM(40)
50.  COMMON/INTCOM/ KR(20),KIN,KOUT,MAT1I,MAT2I,MAT1J,MAT2J,NETA,I,IS,N
51. 18,IT,NTIME,NSP,NSPM1,NAH,NLEQ,NNLEQ,NRNL, ITS,KAPPA,CBAR,CASE(15)
52. 2,B(8), MWE,NON,KQ(10),ITEM,NITEM,KR17,NBT,NBT2,IDENT,KR9(40)
53. 3,KAUXO,JTIME,JSPEC,MD(3)
54.  COMMON/NONCOM/AM(123,123),DVNL(123),TCW,
55. 1VLNKW,DLPH( 7),DLPK( 6, 7),DTHW,DTKW( 6),FLUXJB( 7)
56.  COMMON/PRMCOM/TIME( 50),PRE(40),PTET( 50),GE( 50),S(40),POKAP(40)
57. 1,RNDS,VKAP,NDISC,IDISC(40),NSD(5),MSD(5),ITF( 50),IPRE,RADNO,CONE
58. 2,RADFL( 50),RADR(40),RADG(40),IRAO
59.  COMMON/PRPCOM/PR(15),T(15),RHO(15),SC(15),CAPC(15),QR(15),H(15)
60. 1,CPBAR(15),VMW(15),PHIK(15, 6),DRHOH,DRHOK( 6),ZK( 6),DZKH( 6), D
61. 2MU3K( 6),DMU4K( 6),DTK( 6),DPHIKH( 6),DPRK( 6),DSCK( 6),DCAPCK( 6)

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62. 3,DHTILK( 6),DGRK( 6),DCPBK( 6),DCPTK( 6),DMU12K( 6),DZKK( 6, 6)
63. 4,DPHIKK( 6, 6), DMU4H,DMU3H,DHTILH,VMU12,CT,CTR,CPTIL,HTIL
64. 5,VMU3,DTH,DCAPCH,DPRH,DSCB,DGRH,DCPBH,DCPTH,DMU12H,VMU(15), RHOP
65. 6(15),PHIKP(15),HP,TP,ZKP( 6),VMU3P,VMU4P,HTILP,CRHO(14),GMR(15)
66. COMMON/TEMCOM/SPDUM( 6),DER(40),DUMH1(15),SLOPE(15),REDUM(15)
67. 1,SDUM1(40),SDUM2(40),FWDUM(40),XICON(40),FWCON(40),FWINIT( 1)
68. 2,XIINIT( 1),DUOS( 40)
69. COMMON/VARCOM/F(4,15),G(3,15),SP(3,15, 7),ALPH
70. COMMON/WALCOM/FW(40, 1),TW(40, 1),HW(40, 1),SPW( 6,40, 1)
71. 1,RHOVW(40, 1),FLUXJ( 3,40, 1),IHW,ITW,IFW,ISPW,IRHOVW,IFLUXJ
72. EQUIVALENCE (AM(134),DQJRN(1)),(WALLO, WALLQJ)
73. C EVALUATES REDUCED SET OF DQNL AND DJNL. NOTE...DQNL FOLLOWED BY
74. C DJNL IS EQUIVALENCED TO DQJNL FOR CONVENIENCE OF FOLLOWING LOOP.
75. C ALSO, THE REDUCED SET DQJRN IS EQUIV. TO AM(1) FOR STORAGE ECON.
76. DO 275 I=1, NRNL
77. M = I + NAM
78. L = LAR(M)
79. DO 275 K=1, NSP
80. KN=K+116
81. DQJRN(I,K)=AM(KN,L)
82. DO 275 J=1, NAM
83. JJ = LAR(J)
84. IF (I = 1) 275,270,275
85. 270 ENL(KN)=ENL(KN)+AM(KN,JJ)*ENL(J)
86. 275 DQJRN(I,K)=DQJRN(I,K)+AM(KN,JJ)*AM(J,M)
87. RHOVS = C1 * F(1,1) + HF(1,5)
88. DO 278 K=1, NSP
89. 278 WALLQJ(K)=WALLQJ(K)+ENL(K+116)
90. IF(KR(9)=2) 315,285,315
91. 285 DO 290 L=1,3
92. 290 W(L) = FLUXJ(L,IS,IT)
93. C PREPARE DQJRN AND WALLQJ FOR SURFACE MASS BALANCE
94. 295 WSUM = W(1) + W(2) + W(3)
95. DO 310 K=2, NSP
96. DQJRN(1,K) = DQJRN(1,K) / C1
97. WALLJ(K = 1) = WALLJ(K = 1) - DQJRN(1,K) * RHOVS - DQJRN(2,K) *
98. 1G(1,1)
99. DO 310 KK=3, NRNL
100. 310 WALLJ(K = 1) = WALLJ(K = 1) - DQJRN(KK,K) * SP(1,1,KK = 2)
101. 315 IF (KR(16) = 1) 345,340,320
102. 320 IF (KR(17)) 340,340,335
103. 325 FORMAT(52H DEBUG DQJRN(NRNL,NSP) BY ROWS, DELOW(5),WALLQJ(5)/
104. 1 (8X1P10E10,3))
105. 330 FORMAT(35H DEBUG DQJNL(NNLEQ,NSP) ROW BY ROW /(8X1P10E10,3))
106. 335 WRITE(KOUT,330)((AM(K,I),K=117,KN ),I=1,NNLEQ)
107. 340 WRITE(KOUT,325)((DQJRN(I,K),K=1,NSP),I=1,NRNL),(ENL(K),K
108. 1=117,KN),(WALLQJ(K),K=1,NSP)
109. IX = - 2
110. 345 CONTINUE
111. IF(KIP) 346,346,375
112. 346 IF(KR(9)=2) 347,355,395
113. 347 DRNL(1)=FW(IS,IT)-F(1,1)
114. DRNL(2)=0.
115. IF(NSPM1) 350,350,348
116. 348 DO 349 K=1, NSPM1
117. DRNL(K+2)=SPW(K,IS,IT)-SP(1,1,K)
118. 349 DRNL(2)=DRNL(2)+DRNL(K+2)*DTKW(K)
119. 350 IF(KR(11)) 351,351,352
120. 351 DRNL(2)=(TW(IS,IT)-T(1)-DRNL(2))/DTHW
121. GO TO 595
122. 352 DRNL(2)=HW(IS,IT)-G(1,1)
123. GO TO 595
124. 355 IF (KR(11) = 1) 375,365,360
125. 360 IF (KR(11) = 3) 370,375,370

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126. 365 KQ(1) = 2
127. DRNL(2)=HW(IS,IT)-G(1,1)
128. HIP=(G(1,1)+EASE*(HW(IS,IT)-G(1,1)))/1.8
129. GO TO 380
130. 370 KQ(1)=1
131. IF(T(1)-1000.) 374,374,372
132. 372 IF(EASE=.05) 380,374,380
133. 374 TW(IS,IT)=AMAX1(T(1),1500.)
134. 375 HW(IS,IT)=G(1,1)+CPBAR(1)*EASE*(TW(IS,IT)-T(1))
135. T(1)=T(1)+EASE*(TW(IS,IT)-T(1))
136. KIP=MAX0(KIP-1,0)
137. 376 KQ(1)=0
138. 380 KQ(6) = 2
139. KQ(4) = 0
140. IF (KR(7))385,385,390
141. 385 CALL EQUIL(KQ,0.,PE(IS,IT))
142. 390 KQ(6) = 0
143. FW(IS,IT) = (RHOVS(IS,IT) - HF(1,5)) / C1
144. IF(KR(11)-1) 391,392,391
145. 391 DRNL(2)=(HW(IS,IT)-G(1,1))/EASE
146. 392 DRNL(1)=FW(IS,IT)-F(1,1)
147. IF(NSPM1) 595,595,393
148. 393 DO 394 K=1,NSPM1
149. 394 DRNL(K+2)=(SPW(K,IS,IT)-SP(1,1,K))/EASE
150. GO TO 595
151. C KIP=1 IF USING ASSIGNED TEMPERATURE ON ENERGY BALANCE FOR TEFLON
152. 395 KIP = 0
153. W(3)=RHOVS-W(2)
154. K9R=KR(9)-2
155. GO TO (450,460,490,400,396),K9R
156. 396 WDOT=0.
157. HPG=HTEF
158. AM(1,5)=0.
159. 400 HMAT = HTEF
160. EMIS = EMIST
161. IF (ITS = 1) 465,465,405
162. 405 IF (TFZ) 465,465,410
163. 410 IF (ABS(T(1) - TFZ) = 10.) 465,435,435
164. 415 IF (DTEMP * DUM2) 440,440,420
165. 420 IF (DUM1 * 20. + WDOT) 425,425,430
166. 425 TFZ = T(1) = 50. / DTEMP * ATEMP
167. BUMP = 1.
168. GOTO 435
169. 430 TFZ = T(1)
170. 435 TW(IS,IT) = TFZ
171. GOTO 445
172. 440 TW(IS,IT) = T(1) + 50. / DTEMP * ATEMP
173. BUMP = 1.
174. 445 KIP = 1
175. GO TO 490
176. 450 DRNL(1)=TW(IS,IT)-T(1)
177. AM(1,4)=0.
178. AM(1,5)=DTHW
179. DO 455 K=1,NSPM1
180. 455 AM(1,K+5)=DTKW(K)
181. 460 HMAT=HCARB
182. EMIS=EMISC
183. 465 TFZ = 0.
184. DUM1 = STEF * EMIS * (T(1)) * * 3. * C3
185. DRNL(2) = - WALLQ + RHOVS * (HMAT = G(1,1)) - DUM1 * T(1) + RADS(
186. 1IS)*C3+W(2)*(HPG-HMAT)
187. DUM2 = DRNL(2)
188. AM(2,4) = OQJRN(1,1) + C1 * (G(1,1) - HMAT)
189. DUM1 = DUM1 * 4.

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190.      AM(2,5) = DQJRN(2,1) + DUM1 * DTHW + RHOVS
191.      DO 470 K=1, NSPM1
192. 470 AM(2,K + 5) = DQJRN(K + 2,1) + DUM1 * DTKW(K)
193.      IF(KR(9).EQ.7) GO TO 500
194.      IF(KR(9)=4) 510,475,495
195. 475 DRNL(1) = VLNKW
196.      DO 472 K=1, IZ
197.      J = -IR(K)
198.      FNU(J) = VNU(ISU, J)
199.      IF (LEF(K) + LEFW(K)) 471,471,472
200. 471 FNU(J) = 0.
201. 472 CONTINUE
202.      DO 476 K=1, IZ
203. 476 DRNL(1) = DRNL(1) + YW(K) * FNU(K)
204.      AM(1,4) = 0.
205.      DUM1 = TCW / T(1)
206.      AM(1,5) = DUM1 * DTHW
207.      DO 477 K=1, IZ
208. 477 AM(1,5) = AM(1,5) - DLPH(K) * FNU(K)
209.      DO 480 K=1, NSPM1
210.      AM(1,K+5) = DUM1 * DTKW(K)
211.      DO 480 KK=1, IZ
212. 480 AM(1,K+5) = AM(1,K+5) - DLPH(K, KK) * FNU(KK)
213.      GOTO 510
214. 490 WDOT = C3 * EXP( (ADUM * TW(IS,IT) + BDUM) * TW(IS,IT) + CDUM)
215.      KIP = KIP + 1
216.      W(3) = WDOT
217.      W(2) = 0.
218.      W(1) = 0.
219.      GOTO 295
220. 495 WDOT = C3 * EXP( (ADUM * T(1) + BDUM) * T(1) + CDUM)
221.      AM(1,5) = WDOT * (ADUM * 2. * T(1) + BDUM)
222. 500 DRNL(1) = W(3) - WDOT
223.      DUM1 = ABS(DRNL(1))
224.      AM(1,4) = - C1
225.      DO 505 K=1, NSPM1
226. 505 AM(1,K + 5) = AM(1,5) * DTKW(K)
227.      AM(1,5) = AM(1,5) * DTHW
228. 510 DO 520 K=1, NSPM1
229.      DRNL(K+2) = -WALLJ(K) - RHOVS * (SP(1,1,K) - TQ(K,L3) * WTM(K)) + W(2) * WTM(K) *
230.      1 (TQ(K,L2) - TQ(K,L3))
231.      DO 515 KK=1, NRNL
232. 515 AM(K + 2, KK + 3) = DQJRN(KK, K + 1)
233.      AM(K+2,4) = AM(K+2,4) + C1 * (SP(1,1,K) - TQ(K,L3) * WTM(K))
234. 520 AM(K + 2, K + 5) = AM(K + 2, K + 5) + RHOVS
235.      II = 0
236.      IF(KR(9)=3) 525,540,525
237. 525 IF(W(3)) 540,530,530
238. 530 DRNL(1) = (WDOT - W(3)) / C1
239.      W(3) = WDOT
240.      DO 535 K=2, NRNL
241. 535 DRNL(K) = DRNL(K) - DRNL(1) * AM(K,4)
242.      II = 1
243. 540 IXX = IX
244.      CALL RERAY(NRNL-II, AM(II+1, II+4), 0, DRNL(II+1), 1, 0, IXX, 123, IP, ALP,
245.      1 FNU, GAMH, GAMF)
246.      IF (KR(9) + KIP = 6) 560,545,560
247. 545 DTEMP = DRNL(2) * DTHW
248.      DO 550 K=1, NSPM1
249. 550 DTEMP = DTEMP + DTKW(K) * DRNL(K + 2)
250.      ATEMP = ABS(DTEMP)
251.      IF (ATEMP = 50.) 555,560,415
252. 555 TFZ = - T(1)
253. 560 CONTINUE
254.      WDOT = W(3)
255. 595 RETURN
256.      END

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B06A, LINCER

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1. CB06A
2. SUBROUTINE LINCER
3. COMMON/EDGCOM/ PE(40, 1),PTE(40, 1),SPE( 6,40, 1),DUES,
4. 1UE(40),RHOE(40),VMUE(40),TE(40),UEDGE,DUEDGE,D2UEDG,VMWE,CGE,C90
5. 2,D8IP(40),IDSIP,TTVC,TVCC(40),HEA(40),SF(20),CS(20),CSPR(20),
6. 3 CG(20),CGP(20),SREF,GEP,NEN
7. COMMON/ERRCOM/FLE( 43),GLE(30),SPLE(30, 6),ELA(253),FLEM,GLEM
8. 1,SPLEM( 6),ELM(14),ELMM,IFLM,IGLM,ISPLM( 6),NELM,ILMM,DPL(43)
9. 2,DGL(30),DSPL(30, 6),FNLE(18),GNLE(15),SPNLE(15, 6),ENL(123)
10. 3,FNLEM,GNLEM,SPNLEM( 6), ENLMM,IFNLM,IGNLM,ISPMLM( 6)
11. 4,NENLM,INLMM,DFNL(18),DGNL(15),DSPNL(15, 6),DRNL( 8)
12. COMMON/ETACOM/ETA(15),DETA(15),DSQ(14),DCU(14),R1(14),R2(14)
13. 1,LAR(123),BA1(43,18),BA2(30,15)
14. COMMON/INTCOM/ KR(20),KIN,KOUT,MAT1I,MAT2I,MAT1J,MAT2J,NETA,I,IS,N
15. 1S,IT,NTIME,NSP,NSPM1,NAM,NLEQ,NNLEQ,NRNL, ITS,KAPPA,CBAR,CASE(15)
16. 2,B(8), MWE,NON,KQ(10),ITEM,NITEM,KR17,NBT,NBT2,IDENT,KR9(40)
17. 3,KAUXO,JTIME,JSPEC,MO(3)
18. COMMON/PRMCOM/TIME( 50),PRE(40),PTET( 50),GE( 50),S(40),ROKAP(40)
19. 1,RNDSE,VKAP,NDISC,IDISC(40),NSD(5),ITF( 50),IPRF,RADNG,CONE
20. 2,RADFL( 50),RADR(40),RAD9(40),IRAD
21. COMMON/VARCOM/F(4,15),G(3,15),SP(3,15, 7),ALPH
22. C EVALUATE LINEAR ERRORS FOR MOMENTUM AND ENERGY
23. NELM=NSP+1
24. NENLM=NELM
25. NUL=0
26. DO 400 I=1,MAT1I
27. 400 BA1(I,1)=0.
28. DO 401 I=2,NETA
29. IF(I=2) 4004,4003,4004
30. 4003 IF(KR(10)) 4000,4000,4001
31. 4004 IF(I=NETA) 4002,4005,4002
32. 4005 IF(KR(10)=1) 4002,4000,4002
33. 4000 DUM1=B(4)
34. DUM2=B(5)
35. DUM3=B(2)
36. DUM4=B(3)
37. DUM5=B(1)
38. DUM6=1.0
39. GO TO 4002
40. 4001 DUM1=B(3)
41. DUM2=0.
42. DUM3=B(1)
43. DUM4=0.
44. DUM5=1.0
45. DUM6=0.
46. 4002 CONTINUE
47. FLE(I-1)=-(F(1,I-1)+DETA(I-1)*F(2,I-1)+DSQ(I-1)/2.*F(3,I-1)+DCU(
48. 1I-1)*(DUM1*F(4,I-1)+DUM2*F(4,I))-F(1,I))
49. M=I+NETA-2
50. FLE(M)=-(F(2,I-1)+DETA(I-1)*F(3,I-1)+DSQ(I-1)*(DUM3*F(4,I-1)+DUM4*
51. 1F(4,I))-F(2,I))
52. M=M+1
53. DO 403 K=NUL,NSPM1
54. SPLE(I,K)=-(SP(1,I-1,K)+DETA(I-1)*SP(2,I-1,K)+DSQ(I-1)*(DUM3*SP(3,
55. 1I-1,K)+DUM4*SP(3,I,K))-SP(1,I,K))
56. 403 SPLE(M,K)=-(SP(2,I-1,K)+DETA(I-1)*DUM5*(SP(3,I-1,K)+DUM6*SP(3,I,K)
57. 1)-SP(2,I,K))
58. M=I+2*NETA-3
59. 401 FLE(M)=-(F(3,I-1)+DETA(I-1)*DUM5*(F(4,I-1)+DUM6*F(4,I))-F(3,I))
60. FLE(MAT1I)=DUM6*(F(3,NETA)-ALPH*ALPH*DUEDGE)
61. BA1(MAT1I,1)=-2.*DUM6*DUEDGE*ALPH

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62.      IF (ABS(BA1(MAT1I,1)).GT.0.) CALL MATS1(BA1)
63.      GLE(1)=-G(1,NETA)-CGE)
64.      GLE(MAT2I)=-DUM6*(G(2,NETA)-ALPH*GEP)
65.      IF(NSPM1)404,404,405
66.      405 DO 402 K=1,NSPM1
67.          SPLE(1,K)=-SP(1,NETA,K)-SPE(K,IS,IT))
68.          SPLE(MAT2I,K)=-SP(2,NETA,K) + DUM6
69.      C   DETERMINE MAXIMUM LINEAR ERRORS
70.      402 CALL ABMAX(MAT2I,SPLE(1,K),SPLEM(K),ISPLM(K))
71.      404 CALL ABMAX(MAT1I,FLE,FLEM,IFLM)
72.          CALL ABMAX(MAT2I,GLE,GLEM,IGLM)
73.          ELM(1)=FLEM
74.          ELM(2)=GLEM*.001
75.          IF(NSPM1)406,406,407
76.      407 DO 486 K=3,NELM
77.      486 ELM(K)=SPLEM(K-2)*.1
78.      406 CALL ABMAX(NELM,ELM,ELMM,ILMM)
79.      C   FORM PRODUCT OF A**=-1 AND LINEAR ERRORS
80.      469 CALL MATS1(FLE)
81.          DO 474 K=NUL,NSPM1
82.      474 CALL MATS2(SPLE(1,K))
83.          RETURN
84.          END

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1.  CB07A
2.  SUBROUTINE REFCON
3.  COMMON/EDGCOM/          PE(40, 1),PTE(40, 1),SPE( 6,40, 1),DUES,
4.  1UE(40),RHOE(40),VMUE(40),TE(40),UEDGE,DUEDGE,D2UEDG,VMWE,CGE,C90
5.  2,DSIP(40),IDSIP,TTVC,TVCC(40),HEA(40),SF(20),CS(20),CSPR(20),
6.  3CG(20),CGP(20),SREF,GEP,NEN,UINF,RHOINF,HINF,PINF
7.  COMMON/HISCOM/C1,C2,C3,C4,ALPHD,BETA,ZH(4,14),ZG(4,14),ZSP(4,14, 6
8.  1 ),XI(40),HF(15,5),HG(15,3),HSP(15,3, 6),HALPH,HUE,HMUE,HFW,OLX2
9.  2,C3M(40),BETAM(40)
10.  3 ,BETAV(40)
11.  COMMON/INTCOM/ KR(20),KIN,KOUT,MAT1I,MAT2I,MAT1J,MAT2J,NETA,I,IS,N
12.  1S,IT,NTIME,NSP,NSPM1,NAM,NLEQ,NNLEQ,NRNL, ITS,KAPPA,CRAR,CASF(15)
13.  2,B(8), MWE,NON,KO(10),ITEM,NITEM,KR17,NBT,NBT2,IDENT,KR9(40)
14.  3,KAUXO,JTIME,JSPEC,MD(3)
15.  COMMON/PRNCOM/TIME( 50),PRE(40),PTET( 50),GE( 50),S(40),ROKAP(40)
16.  1,RNOSE,VKAP,NDISC,IOISC(40),NSD(5),MSD(5),ITF( 50),IPRE,RADNG,CONE
17.  2,RADFL( 50),RADR(40),RADG(40),IRAD
18.  COMMON/TEMCOM/SPDUM( 6),DER(40),DUMM1(15),SLOPE(15),REDUM(15)
19.  1,SDUM1(40),SDUM2(40),FHDUM(40),XICON(40),FWCON(40),FWINIT( 1)
20.  2,XIINIT( 1),DUDS( 40)
21.  COMMON/VARCOM/F(4,15),G(3,15),SP(3,15, 7),ALPH
22.  COMMON/WALCOM/FW(40, 1),TW(40, 1),HW(40, 1),SPW( 6,40, 1)
23.  1,RHOVW(40, 1),FLUXJ( 3,40, 1),IHW,ITW,IFW,ISPW,IRHOVW,IFLUXJ
24.  COMMON/UNICOM/UCD,UCE,UCL,UCH,UCP,UCR,UCS,UCT,UCV,ITDK
25.  1 ,IUNIT,IPLT,KA(2,19)
26.  COMMON/SLPCOM/ KEDGP
27.  EQUIVALENCE(RTM,PTET(9))
28.  NAMELIST/STALIS/PRE,DSIP,RADR,HW,TW,FW,RHOVW,SPW,FLUXJ
29.  DATA IHR/IHR/IHD/IHD/IHI/IHI/IHF/IHF/
30.  7007 FORMAT(7E10,4)
31.  7008 FORMAT(A1,E9.4,7E10.4/(8E10.4))
32.  9001 FORMAT(I3,7E10.3)
33.  106 FORMAT(I2,E8.5,7E10.5)
34.  15 FORMAT(IH1)
35.  14 FORMAT (/,1X,13HWALL LENGTH, A6,4X , 8E12.5/(24X,8E12.5))
36.  16 FORMAT (/,1X,16HAXIAL DISTANCE, A6 ,1X, 8E12.5/(24X,8E12.5))
37.  17 FORMAT (/,1X,23H PRESSURE RATIO ,8E12.5/(24X,8E12.5))
38.  18 FORMAT (/,1X,16HENTROPY CHANGE, A6,1X , 8E12.5/(24X,8E12.5))
39.  19 FORMAT (/,1X,15HWALL ENTHALPY, A6,2X , 8E12.5/(24X,8E12.5))
40.  20 FORMAT (/,1X,17HWALL TEMPERATURE, A6 , 8E12.5/(24X,8E12.5))
41.  21 FORMAT (/,1X,23HWALL STREAM FUNCTION ,8E12.5/(24X,8E12.5))
42.  22 FORMAT (/,1X,11HMASS FLUX, A6 ,6X , 8E12.5/(24X,8E12.5))
43.  23 FORMAT (/,1X,23HELEMENTAL MASS FRACTION,8E12.5/(24X,8E12.5))
44.  24 FORMAT (/,1X,11HCOMP FLUX, A6 ,6X , 8E12.5/(24X,8E12.5))
45.  25 FORMAT (/,1X,17HSTATIC PRESSURE, A6 , 8E12.5/(24X,8E12.5))
46.  26 FORMAT (/,1X, 4HX1,( A6 ,4H)**2, 9X , 8E12.5/(24X,8E12.5))
47.  41 FORMAT (/,1X, 5HBETAV, 18X , 8E12.5/(24X,8E12.5))
48.  27 FORMAT (/,1X, 5HBETAP, 18X , 8E12.5/(24X,8E12.5))
49.  28 FORMAT (/,1X, 8HRADIUS, A6 ,9X , 8E12.5/(24X,8E12.5))
50.  29 FORMAT (/,1X,15HEDGE VELOCITY, A6 ,2X , 8E12.5/(24X,8E12.5))
51.  30 FORMAT (/,1X,23HNORMALIZED MASS FLUX ,8E12.5/(24X,8E12.5))
52.  31 FORMAT (/,1X,23HNORMALIZED COMP FLUX ,8E12.5/(24X,8E12.5))
53.  32 FORMAT (/,1X,17HINCID RAD.FLUX, A6 , 8E12.5/(24X,8E12.5))
54.  33 FORMAT (/,1X,23H-1/FLUX NORM.PARAMETER ,8E12.5/(24X,8E12.5))
55.  34 FORMAT (/,1X,23HSTREAM FUNCTION, LB/SEC ,8E12.5/(24X,8E12.5))
56.  35 FORMAT (/,1X,23HENTROPY CHANGE,BTU/LB R,8E12.5/(24X,8E12.5))
57.  36 FORMAT (/,1X,23HENTHALPH CHANGE,BTU/LB ,8E12.5/(24X,8E12.5))
58.  37 FORMAT (/24H SHOCK ANGLE,DEGREES 8E12.5/(24X8E12.5))
59.  38 FORMAT (/24H SHOCK ANGLE,RADIANS 8E12.5/(24X8E12.5))
60.  1532 IF (ITEM-1) 1539,1538,1539
61.  1538 IDSIP=1

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62.      IPRE=1
63.      IRAD=1
64.      NEN=0
65.      DO 1540 I=1,NS
66. 1540  DSIP(I)=0.
67.      NL=NSD(5)
68.      IF(NL.EQ.0)GO TO 1539
69.      READ(KIN,STALIS)
70.      GO TO 1534
71. 1539  IF (IDSIP=ITEM) 1536,1537,1536
72. 1537  IF(KR(5)=5) 1522,1535,1536
73. 1522  IF(KR(5)=2) 1536,1524,1524
74. 1524  READ(KIN,106) NEN,UNF,RHOINF,HINF,PINF
75.      HINF=HINF/1.8
76.      IF(NEN) 1527,1527,1526
77. 1526  READ(KIN,7008) IRED,(SF(I),I=1,NEN)
78.      IF(IRED.NE.IHI.AND.IRED.NE.IHF) GO TO 1530
79.      DO 1547 I=1,NEN
80.      IF(IRED.EQ.IHI) SF(I)=SF(I)/12.
81.      DUM=RHOINF*UNF*SF(I)
82.      IF(ABS(KR(6)=2),EQ.1)GO TO 1547
83.      DUM=DUM/2.*SF(I)
84. 1547  SF(I)=DUM
85.      GO TO 1530
86. 1527  NEN=NS
87.      DO 1528 I=1,NS
88. 1528  SF(I)=RHOINF*UNF/2.*ROKAP(I)**2
89. 1530  READ(KIN,7008) IRED,(CS(I),I=1,NEN)
90.      WRITE(KOUT,34)(SF(I),I=1,NEN)
91.      IF(IRED.NE.IHD) GO TO 1548
92.      WRITE (KOUT,37)(CS(I),I=1,NEN)
93.      DO 1551 I=1,NEN
94. 1551  CS(I)=CS(I)/57.29577
95.      IRED=IHR
96.      GO TO 1549
97. 1548  IF(IRED.NE.IHR) GO TO 1550
98.      WRITE(KOUT,38)(CS(I),I=1,NEN)
99.      GO TO 1549
100. 1550  WRITE(KOUT,35) (CS(I),I=1,NEN)
101. 1549  IF(KR(5)=4) 1529,1525,1529
102. 1525  READ (KIN,7007) (CG(I),I=1,NEN)
103.      CALL SLOPO (NEN,SF,CG,CGP,DER)
104.      WRITE(KOUT,36)(CG(I),I=1,NEN)
105.      GO TO 1529
106. 1535  READ (KIN,7007) (DSIP(I),I=1,NS)
107.      DO 1570 I=1,NS
108. 1570  DSIP(I)=DSIP(I)*UCE/UCT
109. 1529  CONTINUE
110. 1536  IF (IPRE=ITEM) 1534,1533,1534
111. 1533  IF(ITDK.EQ.0)READ(KIN,7007)(PRE(I),I=1,NS)
112. 1534  IF(PRE(I)) 1541,1542,1541
113. 1542  DO 1543 I=2,NS
114.      IF(PRE(I)) 1544,1543,1544
115. 1544  L=I
116.      GO TO 1545
117. 1543  CONTINUE
118. 1545  RNOSE=S(L)/SQRT(1.-PRE(L))
119.      DO 1546 I=2,L
120. 1546  PRE(I-1)=1.-S(I-1)/RNOSE*S(I-1)/RNOSE
121. 1541  DO 1531 I=1,NS
122.      IF(PTET(2).LE.1.0E-20)PTET(2)=1.0
123.      PRE(I)=PRE(I)/PTET(2)
124.      PTE(I,1)=PTET(ITEM)
125. 1531  PE(I,1)=PTE(I,1)*PRE(I)

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126.      IF (IRAD=ITEM)1554,1552,1554
127. 1552 IF (NL.EQ.0)READ(KIN,7007)(RADR(I),I=1,NS)
128. 1554 DO 1553 I=1,NS
129. 1553 RAD3(I)=RADFL(ITEM)*RADR(I)
130.      105 DO 104 IS=1,NS
131. 201 IF (IS=1) 207,207,203
132. 207 KQ(1)=2
133.      KQ(5)=2
134.      KQ(6)=0
135.      KQ(4)=0
136.      DUM=UE(1)
137.      IF (KR(7))8003,8003,8002
138. 8002 CALL STATE
139.      WRITE(KOUT,992)
140.      WRITE(KOUT,994)
141.      N=IUNIT+1
142.      WRITE(KOUT,993)KA(N,9),KA(N,5),KA(N,15),KA(N,2),KA(N,8),KA(N,14)
143.      1,KA(N,7),KA(N,1),KA(N,15)
144. 992 FORMAT(1H1,12X15HEDGE CONDITIONS//)
145. 993 FORMAT(7X,A6,7X,A6,5X,A6,7X,A6,5X,A6,6X,A6,8X,A6,5X,A6,5X,A6)
146. 994 FORMAT(2X,2HIS,3X116H WALL      TEMP      CP      STATIC
147.      1 DENSITY      VISCOSITY      VELOCITY      ENTHALPY      ENTROPY      MACH
148.      2 NO. /
149.      35X46H LENGTH      FROZEN      PRESSURE )
150.      GO TO 8004
151. 8003 CALL EQUIL(KQ,GE(ITEM),PTE(1,IT))
152. 8004 KQ(1)=3
153.      KQ(2)=0
154.      KQ(3)=6
155.      KQ(5)=1
156.      IF(KR(6)=2) 210,203,203
157. 203 IF(ITF(15).EQ.0)GO TO 2031
158.      IF(IS.EQ.1) UE(1)=DUM
159.      CGE=GE(ITEM)-UE(IS)*UE(IS)/50073.
160.      IF(KR(7).EQ.0) GO TO 8106
161.      CALL STATE
162.      GO TO 210
163. 8106 WRITE(KOUT,12)IS
164.      KQ(1)=2
165.      CALL EQUIL(KQ,CGE,PE(IS,IT))
166.      GO TO 210
167. 2031 CONTINUE
168.      IF(KR(7).EQ.0) GO TO 8006
169. 8005 CALL STATE
170.      GO TO 210
171. 8006 WRITE(KOUT,12) IS
172.      12 FORMAT(2X,11HSTATION NO.,I3)
173.      CALL EQUIL(KQ,0.,PE(IS,IT))
174.      210 IF (NSPM1)205,205,215
175.      215 DO 216 K=1,NSPM1
176.      216 SPE(K,IS,IT)=SP(1,NETA,K)
177.      205 IF(KR(15)) 9903,9904,9903
178. 9903 WRITE(KOUT,9901) IS,HEA(IS),UE(IS),PTE(IS,1),TE(IS),RHOE(IS)
179.      1,VMUE(IS)
180. 9904 CONTINUE
181. 104 CONTINUE
182.      IF(IREDD.NE.IHR)GO TO 103
183.      KQ(1)=2
184.      KQ(5)=3
185.      DO 102I=1,NEN
186.      CALL EQUIL(KQ,CS(I),PTE(1,1))
187.      IF(I.EQ.1) CS1=CS(1)
188. 102 CS(I)=CS(I)-CS1
189. 103 IF(NEN.GT.0)CALL SLOPO(NEN,SF,CS,CSPR,DER)

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190. C      END OF EDGE PROPERTY LOOP, START OF BETA AND XI CALCULATION
191. 605 XI(1)=0.
192.      J=NDISC+1
193.      LL=1
194.      NSM=NS-1
195.      DO 111 II=1,J
196.      K=2
197.      M=LL
198.      MM=M+1
199.      IF(MM.EQ.NS) GO TO 602
200.      DO 601 IX=MM,NSM
201.      IF(IDISC(IX).EQ.1) GO TO 602
202. 601 K=K+1
203. 602 CONTINUE
204.      LL=K+M-1
205.      IF (II=1) 6052,6052, 402
206. 6052 IF (KR(6)=1) 400,401,402
207. C      AXISYMETRIC BLUNT
208. 400 DO 403 I=M,LL
209.      SDUM2(I)=S(I)*S(I)
210.      IF(S(I)) 403,403,4031
211. 4031 DUM1=ROKAP(I)/S(I)
212.      XICON(I)=UE(I)/S(I)*RHOE(I)/4.*VMUE(I)*DUM1*DUM1
213. 403 SDUM1(I)=SDUM2(I)*SDUM2(I)
214.      QI=4.
215.      BETAM(1)=0.5
216.      GO TO 406
217. C      PLANAR BLUNT
218. 401 DO 404 I=M,LL
219.      SDUM2(I)=S(I)
220.      IF(S(I)) 404,404,4041
221. 4041 XICON(I)=UE(I)/S(I)*RHOE(I)/2.*VMUE(I)
222. 404 SDUM1(I)=S(I)*S(I)
223.      QI=2.
224.      BETAM(1)=1.
225.      GO TO 406
226. 402 IF (KR(6)=2) 408,407,408
227. C      AXISYMETRIC SHARP
228. 407 DO 409 I=M,LL
229.      SDUM2(I)=S(I)*S(I)
230.      DUM1=ROKAP(I)/S(I)
231.      XICON(I)=RHOE(I)*UE(I)*VMUE(I)*DUM1/3.*DUM1
232. 409 SDUM1(I)=S(I)*SDUM2(I)
233.      XI(1) =XICON(1)*S(1)*S(1)*S(1)
234.      QI=3.
235.      IF (II=1) 4051,4051,406
236. C      PLANAR SHARP
237. 408 DO 405 I=M,LL
238.      SDUM2(I)=S(I)
239.      XICON(I)=RHOE(I)*UE(I)*VMUE(I)*ROKAP(I)*ROKAP(I)
240. 405 SDUM1(I)=S(I)
241.      QI=1.
242.      IF (II=1) 4052,4052,406
243. 4052 XI(1) =XICON(1)*S(1)
244. 4051 MM=M
245. 406 CONTINUE
246.      IF(ITF(14).NE.0)GO TO 4012
247. C      CALCULATE VEL. GRAD. IF NEEDED
248.      IF(KEDGP=1) 4010,4011,4011
249. 4010 CALL SLOPQ(K,S(M),UE(M),DUDS(M),DER(M))
250.      GO TO 4012
251. 4011 CALL SLOPL(K,S(M),UE(M),DUDS(M),DER(M))
252. 4012 CONTINUE
253.      IF (KR(6)=2) 4066,4062,4062

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254. 4066 IF (M=1) 4061,4061,4062
255. 4061 IF (RNOSE) 4063,4063,4064
256. COMMENT...DUES COMPUTED BY SLOPD
257. 4063 DUES=DUDS(1)
258. GO TO 4065
259. COMMENT...DUES FROM EFFECTIVE NOSE RADIUS USING NEWTONIAN FLOW
260. 4064 DUES=SQRT(2./RHOE(1)*PE(1,IT)*32.1740*2116.)/RNOSE
261. 4065 XICON(1)=RHOE(1)*VMUE(1)/(2.*VKAP+2.)*DUES
262. 4062 IF (KEDGP=1) 4013,4014,4014
263. 4013 CALL SLOPD(K,SDUM1(M),XICON(M),DER(M),XI(M))
264. GO TO 4015
265. 4014 CALL SLOPL(K,SDUM1(M),XICON(M),DER(M),XI(M))
266. 4015 CONTINUE
267. IF (LL-MM) 111,4101,4101
268. C SKIP BETAV CAL. WHEN DPDS CALCULATED FROM PRESSURE INPUT
269. 4101 IF (ITF(14).NE.0)GO TO 4102
270. DO 410 L=MM,LL
271. BETAV(L)=2./QI*X1(L)/UE(L)*S(L)/SDUM1(L)*DUDS(L)/XICON(L)
272. 410 BETAM(L)=BETAV(L)
273. GO TO 111
274. 4102 A2=RTM*UCL
275. A1=PTET(1)/PTET(2)/A2*2116.2*32.1740
276. C A1 AND A2 FIX THE UNITS AND UNNORMALIZE BETAM AND BETAV
277. C AS THEY COME FROM GEOM
278. DO 4103 L=MM,LL
279. A=2./QI*X1(L)/UE(L)*S(L)/SDUM1(L)/XICON(L)
280. BETAM(L)=-BETAM(L)*A1/RHOE(L)/UE(L)*A
281. IF (ITF(15).EQ.0)GO TO 4104
282. BETAV(L)=BETAV(L)/RTM*A
283. GO TO 4103
284. 4104 BETAV(L)=BETAM(L)
285. 4103 CONTINUE
286. 111 CONTINUE
287. 9A03 FORMAT(8E10,4)
288. WRITE(KOUT,15)
289. V=UCM*UCM
290. DO 411 I=1,NS
291. SDUM1(I)=ROKAP(I)/UCL
292. SDUM2(I)= PE(I,1)/UCP
293. DER(I) =S(I)/UCL
294. DUDS(I)=DSIP(I)/UCE*UCT
295. FWDUM(I)=UE(I)/UCL
296. XICON(I)=XI(I)/V
297. 411 FWCON(I)=RADS(I)/UCR
298. N=IUNIT+1
299. NSX=NS+10
300. WRITE(KOUT,16) KA(N,9), (PTET(I),I=11,NSX)
301. WRITE(KOUT,14) KA(N,9), (DER(I),I=1,NS)
302. WRITE(KOUT,28) KA(N,9), (SDUM1(I),I=1,NS)
303. WRITE(KOUT,26) KA(N,10), (XICON(I),I=1,NS)
304. WRITE(KOUT,17) ( PRE(I),I=1,NS)
305. WRITE(KOUT,25) KA(N,2), (SDUM2(I),I=1,NS)
306. IF (KR(5).EQ.5)WRITE(KOUT,18) KA(N,15), (DUDS(I),I=1,NS)
307. WRITE(KOUT,29) KA(N,7), (FWDUM(I),I=1,NS)
308. WRITE(KOUT,41) ( BETAV(I),I=1,NS)
309. WRITE(KOUT,27) (BETAM(I),I=1,NS)
310. WRITE(KOUT,32) KA(N,11), (FWCON(I),I=1,NS)
311. IF (IPLOT.NE.1)GO TO 412
312. C OUTPUT FOR PLOT
313. KPLT=MSD(2)
314. WRITE(KPLT)PTET(1),GE(1),NS,DER,XICON,(PTET(I),I=11,50),SDUM1,
315. 1 SDUM2,FWDUM,BETAM,BETAV
316. 412 CONTINUE
317. C CALCULATION OF C3 MATRIX

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318.      DO 138 I=1,NS
319.      IF (KR(6)-1) 137,137,158
320.      137 IF (I-1) 139,139,158
321.      139 C3M(I)=-SQRT (BETAM(I)/(DUES*RHOE(I)*VMUE(I)))
322.      GO TO 138
323.      158 C3M(I)=-SQRT(2.*XI(I))/(RHOE(I)*ROKAP(I)*UE(I)*VMUE(I))
324.      138 CONTINUE
325.      C READ WALL CONDITIONS IF UNCOUPLED
326.      JRHOVW=0
327.      IF (ITEM-1) 108,108,7004
328.      108 IHW=1
329.      ITW=1
330.      IFW=1
331.      IRHOVW=1
332.      ISPW=1
333.      IFLUXJ=1
334.      DO 49 I=1,NS
335.      DO 49 L=1,3
336.      49 FLUXJ(L,I,1) = 0.
337.      107 IF (KR(9)-3) 7054,7005,1071
338.      1071 IF(KR(9)-5) 7047,7005,7047
339.      7054 IF(KR(11)-2) 7062,7040,7047
340.      7062 IF(KR(11)) 7004,7005,7004
341.      7004 IF (IHW-ITEM) 1091,109,1091
342.      1091 IF( IHW-1) 1201,7005,1201
343.      109 IF(NL.EQ.0)READ(KIN,7007)((HW(J,JJ),JJ=1,NTIME),J=1,NS)
344.      1201 WRITE(KOUT,19) KA(N,1), (HW(I,1),I=1,NS)
345.      DO 1171 J=1,NS
346.      1171 HW(J,1)=HW(J,1)*UCE
347.      IF (ITEM-1) 7038,7038,7060
348.      7005 IF (ITW-ITEM)1092,110,1092
349.      1092 IF( ITW-1) 1202,7060,1202
350.      110 IF(NL.EQ.0)READ(KIN,7007)((TW(J,JJ),JJ=1,NTIME),J=1,NS)
351.      1202 WRITE(KOUT,20) KA(N,5), (TW(I,1),I=1,NS)
352.      DO 1172 J=1,NS
353.      1172 TW(J,1)=TW(J,1)*UCT
354.      IF (ITEM-1) 117,117,7060
355.      117 IF (KR(9)-3) 7038,7047,7047
356.      7038 IF(KR(9)-1) 7060,7061,7040
357.      7060 IF (IFW-ITEM) 1093,112,1093
358.      1093 IF( IFW-1) 1203,7061,1203
359.      112 IF(NL.EQ.0)READ(KIN,7007)((FW(J,JJ),JJ=1,NTIME),J=1,NS)
360.      1203 WRITE (KOUT,21)(FW(I,1),I=1,NS)
361.      GO TO 7006
362.      7061 IF (IRHOVW-ITEM) 1094,118,1094
363.      1094 IF(IRHOVW-1) 1204,7006,1204
364.      118 IF(NL.EQ.0)READ(KIN,7007)((RHOVW(J,JJ),JJ=1,NTIME),J=1,NS)
365.      JRHOVW=1
366.      1204 IF(KR(8)-JRHOVW) 1102,1101,1101
367.      1102 WRITE(KOUT,22) KA(N,12),(RHOVW(I,1),I=1,NS)
368.      V=UCM/(UCL*UCL)
369.      DO 1173 J=1,NS
370.      1173 RHOVW(J,1)=RHOVW(J,1)*V
371.      GO TO 7006
372.      1101 WRITE (KOUT,30)(RHOVW(I,1),I=1,NS)
373.      7006 IF(NSPM1) 7043,7043,7015
374.      7015 IF (ISPW-ITEM) 1095,114,1095
375.      1095 IF( ISPW-1) 1205,7040,1205
376.      114 DO 7014 K=1,NSPM1
377.      7014 IF(NL.EQ.0)READ(KIN,7007)((SPW(K,J,JJ),JJ=1,NTIME),J=1,NS)
378.      1205 DO 1097 K=1,NSPM1
379.      1097 WRITE (KOUT,23)( SPW(K,I,1),I=1,NS)
380.      GO TO 7043
381.      7040 IF (IFLUXJ-ITEM)1096,115,1096

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B07A. REFCON

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382. 1096 IF(IFLUXJ-1) 1206,7043,1206
383. 115 DO 7041 K=1,3
384. 7041 IF(NL.EQ.0)READ(KIN,7007)((FLUXJ(K,J,JJ),JJ=1,NTIME),J=1,NS)
385. JRHOVW=1
386. 1206 DO 1098 K=1,3
387. IF(KR(8)-JRHOVW) 1104,1103,1103
388. 1104 WRITE(KOUT,24) KA(N,12),(FLUXJ(K,I,1),I=1,NS)
389. DO 7039 J=1,NS
390. 7039 FLUXJ(J,K,1)=FLUXJ(J,K,1)+C3M(J)*V
391. GO TO 1098
392. 1103 WRITE (KOUT,31)(FLUXJ(K,I,1),I=1,NS)
393. 1098 CONTINUE
394. GO TO 7047
395. 7043 IF(JRHOVW) 7047,7047,7045
396. C CALCULATE FW IF RHOVW GIVEN
397. 7045 J=NDISC+1
398. LL=1
399. NSM=NS-1
400. DO 7046 II=1,J
401. K=2
402. M=LL
403. MM=M+1
404. DO 603 IX=MM,NSM
405. IF(IDISC(IX).EQ.1) GO TO 604
406. 603 K=K+1
407. 604 LL=K+M-1
408. DO 209 I=M,LL
409. IF (KR(8)) 7049,7049,2291
410. 7049 RHOVW(I,IT)=RHOVW(I,IT)*C3M(I)
411. 2291 IF (II=1) 7048,7048,230
412. 7048 IF (KR(6)) 229,229,230
413. C VALID AT AXISYMETRIC STAGNATION POINT ONLY
414. 229 FWCON(I)=-RHOVW(I,IT)/(2.*C3M(I))
415. IF( I=1) 209,209,232
416. C MODIFICATION FOR AXISYMETRIC BLUNT AWAY FROM STAGNATION POINT
417. 232 FWCON( I)=FWCON( I)/S( I)*ROKAP( I)
418. GO TO 209
419. C VALID FOR ALL PLANAR
420. 230 FWCON(I)=-RHOVW(I,IT)/C3M(I)*ROKAP(I)
421. IF(KR(6)=2) 209,236,209
422. C MODIFICATION FOR AXISYMETRIC SHARP
423. 236 FWCON( I)=FWCON( I)/S( I)*ROKAP( I)/2.
424. 209 FLUXJ(2,I,1)=RHOVW(I,1)
425. FWDUM(1)=FWCON(1)*S(1)
426. IF(KR(6)=2) 241,237,241
427. C MODIFICATION FOR AXISYMETRIC SHARP
428. 237 FWDUM(1)=FWDUM(1)*S(1)
429. 241 CONTINUE
430. 7046 CALL SLOPO(K,SDUM2(M),FWCON(M),DER(M),FWDUM(M))
431. DO 126 I =1,NS
432. IF(I =1) 124,124,123
433. 124 IF (KR(6)=1) 133,133,123
434. 133 IF (S(I)) 113,113,123
435. 113 FW(1,IT)=RHOVW(1,IT)
436. GO TO 126
437. 123 FW(I ,IT)=FWDUM(I )/SQRT (2.*XI(I ))
438. 126 CONTINUE
439. 7047 RETURN
440. END

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B07B. MISCIN

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1. SUBROUTINE MISCIN
2. COMMON/BLGCOM/MQA(60),MQB(60),NSPEC,FR(60,15),W(3),LEF(8),LEFS(8)
3. 1,PIEASE,LEFW(8)
4. COMMON/CRBCOM/HCARB,EMIS,STEF,ADUM,BDUM,CDUM,MTEF,HMAT,EMISC,EMIST
5. 1,HPG,ASU(3),BSU(3),HPYG(3),HCHAR(3),EMIV(3),K9(40),ISU
6. COMMON/ETACOM/ETA(15),DETA(15),DSQ(14),DCU(14),B1(14),B2(14)
7. 1,LAR(123),BA1(43,18),BA2(30,15)
8. COMMON/EPSCOM/ELCON,YAP,CLNUM,SCT,PRT,RED,DVS,RHOVS,PI,PTM,CL,
9. 1 EPSA(15),EPS1,EL(15),DPI(15,2),OEPC,TREF,RETR,VINTR(15)
10. COMMON/INTCOM/KR(20),KIN,KOUT,MAT1I,MAT2I,MAT1J,MAT2J,NETA,I,IS,NS
11. 1,IT,NTIME,NSP,NSPM1,NAM,NLEQ,NNLEQ,NRNL,ITS,KAPPA,CBAR,CASE(15),
12. 2B(8),MWE,NON,KQ(10),ITEM,NITEM,KR17,NBT,NBT2,IDENT,KR9(40),KAIXO,
13. 3JTIME,JSPEC,MD(3),IU,ISH,KONRFT
14. COMMON/RFTCOM/F2FIX(15),KR10,NPM1,NPOINT,RATLIM,
15. 10UMU(15),KTURB,KAPPAT,NETAT,F2FIXT(15)
16. COMMON/PRMCOM/TIME(50),PRE(40),PTET(50),GE(50),S(40),ROKAP(40),
17. 1RNOSE,VKAP,NDISC,IDISC(40),NSD(5),MSD(5),ITF(50),IPRE,RADNO,CONE,
18. 2RADFL(50),RADR(40),RAD8(40),IRAD
19. COMMON/UNICOM/UCD,UCE,UCL,UCM,UCP,UCR,UCS,UCT,UCV,ITDK,
20. 1UNIT,IPLT,KA(2,19)
21. COMMON/SLPCOM/KEDGP
22. COMMON/VARCOM/F(4,15),G(3,15),SP(3,15,7),ALPH
23. EQUIVALENCE (G(1,1),GW),(ITF(13),IST),(NSD(5),NL)
24. NAMELIST/MISLIS/NSP,KS,NS,KR9,IDISC,S,RTM,ROKAP,NETA,NETAT,ETA,
25. 1KAPPA,KAPPAT,CBAR,KONRFT,NPOINT,RATLIM,KTURB,F2FIX,F2FIXT,
26. 2GE(1),PTET(1),PTET(2),RADFL(1),ELCON,YAP,CLNUM,SCT,PRT,RETR
27. 3,ALPH,F,IST,G,SP,LEF,GW
28. EQUIVALENCE(RTM,PTET(9))
29. IF(KR(1).EQ.0) GO TO 103
30. IF(KR(7).LE.1)GO TO 100
31. NETA=12
32. ETA(1)=0.0
33. ETA(2)=0.002
34. ETA(3)=0.006
35. ETA(4)=0.01
36. ETA(5)=0.025
37. ETA(6)=0.06
38. ETA(7)=0.15
39. ETA(8)=0.4
40. ETA(9)=0.7
41. ETA(10)=1.0
42. ETA(11)=1.5
43. ETA(12)=2.5
44. KAPPA=10
45. F2FIX(1)=0.0
46. F2FIX(2)=0.05
47. F2FIX(3)=0.12
48. F2FIX(4)=0.25
49. F2FIX(5)=0.35
50. F2FIX(6)=0.45
51. F2FIX(7)=0.6
52. F2FIX(8)=0.75
53. F2FIX(9)=0.85
54. F2FIX(10)=0.95
55. F2FIX(11)=0.98
56. F2FIX(12)=1.0
57. GO TO 101
58. 100 NETA=7
59. ETA(1)=0.0
60. ETA(2)=0.5
61. ETA(3)=1.0

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B07B. MISCIN

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62.      ETA(4)=1.5
63.      ETA(5)=2.0
64.      ETA(6)=3.0
65.      ETA(7)=5.0
66.      KAPPA=6
67.      F2FIX(1)=0.0
68.      F2FIX(2)=0.2
69.      F2FIX(3)=0.4
70.      F2FIX(4)=0.6
71.      F2FIX(5)=0.8
72.      F2FIX(6)=0.95
73.      F2FIX(7)=1.0
74.      101 RATLIM=0.5
75.      NPOINT=3
76.      CBAR=0.95
77.      103 CONTINUE
78.      ELCON= 0.44
79.      YAP= 11.823
80.      CLNUM= 0.018
81.      SCT= 0.9
82.      PRT= 0.9
83.      READ(KIN,MISLIS)
84.      IF(KONRFT,NE,0) KR10=KR(10)
85.      IF(KTURB,NE,0) NPM1=NPOINT-1
86.      IF(NETA.LE.15.AND.NETAT.LE.15)GO TO 102
87.      WRITE(KOUT,1)
88.      1 FORMAT(21H TOO MANY NODAL POINTS)
89.      STOP
90.      102 CONTINUE
91.      RETURN
92.      END

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1.  CB08B
2.  SUBROUTINE ICOEFF
3.  COMMON/COECOM/ C5,C6,C7,C8,C9,C10,C11,C12,C13,C14,C15
4.  1,C16,C17,C18,C19,C20,C21,C22,C23,C24,C25,C26,C27,C28,C29,C30,C31,C
5.  232,C33,C34,C35,C36,C37,C38,C39,C40,C41,C42,C43,C44,C45,C46,C47,C48
6.  3,C49,C50,C51,C52,C53,C54,C55,C56,C57,C58,C59,C60,C61,C62,C63,C64,C
7.  465,C66,C67,C68,C69,C70,C71,C72,C73,C74,C75,C76,C77,C78,C79,C80,C81
8.  5,C82,C83,C84,C85,C86,C87,C88
9.  COMMON/COECON/ CK1( 6),CK2( 6),CK3( 6),CK4( 6),CK5( 6),CK6( 6)
10. 1,CK7( 6),CK8( 6),CK9( 6),CK10( 6),CK11( 6),CK12( 6),CK13( 6)
11. 2,CK14( 6),CK15( 6),CK16( 6),CK17( 6),CK18( 6),CK19( 6),CK20( 6)
12. 3,CK21( 6),CK22( 6),CKK1( 6, 6),CKK2( 6, 6),XM(5),XG(5),XSP(5, 7)
13. 4,CKK3( 6, 6)
14. COMMON/EDGCOM/ PE(40, 1),PTE(40, 1),SPE( 6,40, 1),DUES,
15. 1UE(40),RHOE(40),VMUE(40),TE(40),UEGE,DUEGE,D2UEGE,VMUE,HE,C90
16. 2,DSIP(40),IDSIP,TTVC,TVCC(40)
17. COMMON/ETACOM/ETA(15),DETA(15),DSG(14),DCU(14),B1(14),B2(14)
18. 1,LAR(123),BA1(43,18),BA2(30,15)
19. COMMON/HISCOM/C1,C2,C3,C4,ALPHD,BETA,ZM(4,14),ZG(4,14),ZSP(4,14, 6
20. 1),XI(40),HF(15,5),HG(15,3),HSP(15,3, 6),HALPH,HUE,HMUE,HFW,DLX2
21. 2,C3M(40),BETAM(40)
22. COMMON/INTCOM/ KR(20),KIN,KOUT,MAT1I,MAT2I,MAT1J,MAT2J,NETA,I,IS,N
23. 18,IT,NTIME,NSP,NSPM1,NAM,NLEQ,NNLEQ,NRNL, ITS,KAPPA,CBAR,CASE(15)
24. 2,B(8), MWE,NON,KQ(10),ITEM,NITEM,KR17,NBT,NRT2,IDENT,KR9(40)
25. 3,KAUXO,JTIME,JSPEC,MD(3)
26. COMMON/PRPCOM/PR(15),T(15),RHO(15),SC(15),CAPC(15),OR(15),H(15)
27. 1,CPBAR(15),VMW(15),PHIK(15, 6),DRHOK,DRHOK( 6),ZK( 6),DZKH( 6), D
28. 2MU3K( 6),DMU4K( 6),DTK( 6),DPHIKH( 6),DPRK( 6),DSCK( 6),DCAPCK( 6)
29. 3,DHTILK( 6),DQRK( 6),DCPBK( 6),DCPTK( 6),DMU12K( 6),DZKK( 6, 6)
30. 4,DPHIKK( 6, 6), DMU4H,DMU3H,DHTILH,VMU12,CT,CTR,CPTIL,HTIL
31. 5,VMU3,DTH,DCAPCH,DPRH,DSCH,DQRH,DCPBH,DCPTH,DMU12H,VMU(15), RHOP
32. 6(15),PHIKP(15),HP,TP,ZKP( 6),VMU3P,VMU4P,HTILP,CRHO(14),GMR(15)
33. COMMON/VARCOM/F(4,15),G(3,15),SP(3,15, 7),ALPH
34. C FIRST, EVAL DERIVATIVES OF STATE PROPERTIES WITH RESPECT TO ETA
35. VMU4P=DMU4H*HP
36. VMU3P=DMU3H*HP
37. HTILP=DHTILH*HP
38. TP=DTH*HP
39. RHOP(I)=DRHOK*HP
40. IF(NSPM1)401,401,402
41. 402 DO 408 K=1,NSPM1
42. ZKP(K)=DZKH(K)*HP
43. PHIKP(K)=DPHIKH(K)*HP
44. VMU4P=VMU4P+DMU4K(K)*SP(2,I,K)
45. VMU3P=VMU3P+DMU3K(K)*SP(2,I,K)
46. HTILP=HTILP+DHTILK(K)*SP(2,I,K)
47. TP=TP+DTK(K)*SP(2,I,K)
48. RHOP(I)=RHOP(I)+DRHOK(K)*SP(2,I,K)
49. DO 408 J=1,NSPM1
50. ZKP(K)=ZKP(K)+DZKH(K,J)*SP(2,I,J)
51. 408 PHIKP(K)=PHIKP(K)+DPHIKH(K,J)*SP(2,I,J)
52. C NEXT, EVALUATE OTHER GROUPINGS FOR USE AT I AND I-1
53. 401 C11=C5 * F(3,I) * TTVC
54. C12 = C5 * CAPC(I)* TTVC
55. C14=C1*F(1,I)+HF(I,5)
56. C15=PR(I)-1,
57. C16=1./PR(I)
58. C17=1./SC(I)
59. C18=CTR*T(I)
60. C19=C17*C12
61. C20=C16*C12

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62.      C21 = C13 * C15
63.      C22 = C21 * C20
64.      C23 = DCAPCH/CAPC(I)
65.      C24 = C20 * (G(2,I)-C21*F(2,I))
66.      C25 = C20 * C16 * (G(2,I)+C13*F(2,I))
67.      C26 = RHOE(13)/RHO(I)
68.      C28 = C12 * F(3,I)
69.      C31 = HTILP-(CPTIL+CT/VMU(2*CTR)*TP+C18 * VMU3P+(HTIL-H(I)+CTR*
70. 1 VMU3* Y(I)) *VMU4P
71.      C32 = (-F(2,I)*C13+TP/PR(I)*CPBAR(I)+C31/SC(I)) * C12 - C3*QR(I)
72. 1 *TTVC
73.      C43=C24*C23-C25*DPRH-C3*DQRH*TTVC
74.      C53=RHOP(I)/RHO(I)
75.      C56 = F(2,I)/ALPH
76.      C73 = C1 * F(2,I)
77.      C74 = C11 * C10 * DCAPCH + C14
78.      C75=C11*DCAPCH
79.      C76=C1*G(1,I)
80.      C77=-C22+C43*C10
81.      C78=-C20+C15*C10
82.      C79=C43
83.      C80=C20
84.      C81=-C28*(C10*C56*C23+C5)
85.      C82=-C20*C5*G(2,I)+3.0*C22*C56-C43*C10*C56
86.      C83=C28+C14 * F(2,I)
87. 412 C84=C32+G(1,I)*C14
88.      C85 = -C6/RHO(I)*C26/2.
89.      C86=C85+C10*DRHOM
90.      C87=BETA*ALPH*C26-C86*C56
91.      C88=C85*DRHOM
92.      DUM1=C23-DSCH/SC(I)
93.      IF(NSPM1)403,403,404
94. 404 DO 406 K=1,NSPM1
95.      CK3(K) = DCAPCK(K)/CAPC(I)
96. 406 CK4(K)=CK3(K)-DSCK(K)/SC(I)
97.      DO 410 K=1,NSPM1
98.      DUM2=C19 * SP(2,I,K)
99.      CK1(K)=C24*CK3(K)-C25*DPRK(K)-C3*DQRK(K)*TTVC
100.      CK2(K)=0.
101.      CK5(K)=0.
102.      DUM3=ZK(K)-SP(1,I,K)
103.      CK6(K)=C19*(ZKP(K)+VMU4P*DUM3)
104.      CK9(K)= DUM2*DUM1
105.      CK13(K)=C85*DRHOK(K)
106.      CK14(K)=0.
107.      CK15(K)=0.
108.      CK16(K)=0.
109.      CK17(K)=C11*DCAPCK(K)
110.      CK18(K)=C1*SP(1,I,K)
111.      CK19(K)=CK9(K)*C10
112.      CK20(K)=0.
113.      CK21(K)=-CK19(K)*C56-DUM2/ALPH
114. 414 CK22(K)=CK6(K)+SP(1,I,K)*C14
115.      DO 410 KK=1,NSPM1
116.      CKK1(K,KK)=C19*(DZKK(K,KK)+DUM3*DMU4K(KK))
117.      CKK3(K,KK)=DPHIKK(K,KK)
118. 410 CKK2(K,KK)=DUM2*CK4(KK)
119. 403 CONTINUE
120.      RETURN
121.      END

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1.  C809A
2.  SUBROUTINE RECASE
3.  COMMON/CRBCOM/HCARB,EMIS,STEF,ADUM,BDUM,CDUM,HTEF,HMAT,EMISC,EMIST
4.  1,HPG,ASU(3),BSU(3),HPYG(3),HCHAR(3),EMIV(3),KS(40),ISU
5.  COMMON/ETACOM/ETA(15),DETA(15),DSQ(14),DCU(14),B1(14),B2(14)
6.  1,LAR(123),BA1(43,18),BA2(30,15)
7.  COMMON/INTCOM/ KR(20),KIN,KOUT,MAT1I,MAT2I,MAT1J,MAT2J,NETA,I,IS,N
8.  18,IT,NTIME,NSP,NSPM1,NAM,NLEG,NNLEG,NRNL, ITS,KAPPA,CBAR,CASE(15)
9.  2,B(8), MWE,NON,KQ(10),ITEM,NITEM,KR17,NBT,NBT2,IDENT,KR9(40)
10. 3,KAUXO,JTIME,JSPEC,MD(3),IU,ISH
11. 4,KONRFT
12.  COMMON/RFTCOM/ F2FIX(15),KR10,NPM1,NPOINT,RATLIM
13. 1,DUMU(15),KTURB,KAPPAT,NETAT,F2FIXT(15)
14.  COMMON/PRMCOM/TIME( 50),PRE(40),PTET( 50),GE( 50),S(40),ROKAP(40)
15. 1,RNOSE,VKAP,NDISC,IDISC(40),NSD(5),MSD(5),ITF( 50),IPRE,RADNO,CONE
16. 2,RADFL( 50),RADR(40),RADS(40),IRAD
17.  COMMON/UNICOM/UCD,UCE,UCL,UCM,UCP,UCR,UCS,UCT,UCV,ITDK
18. 1,IUNIT,IPLT,KA(2,19)
19.  COMMON/SLPCOM/ KEDGP
20.  EQUIVALENCE(RTM,PTET(9))
21. 1 FORMAT(20I1,15A4)
22. 2 FORMAT(I2)
23. 3 FORMAT(I2/(7E10,4))
24. 4 FORMAT(1H114X47HJANNAF BOUNDARY LAYER INTEGRAL MATRIX PROCEDURE
25. 1//,25X,25HBLIMP-J MOD 2 JULY 1975 ,
26. 5//8X,44HACUREX CORP. AEROTHERM DIV.,MT. VIEW,CALIF.,2X3A6//1X ,5H
27. 2CASE ,15A4,///,8X,75HCONTROL NUMBERS 1 2 3 4 5 6 7 8 9 10
28. 311 12 13 14 15 16 17 18 19 20,///,23X,20I3)
29. 5 FORMAT(7E10,4)
30. 6 FORMAT (I2,E10.4,2I2,F10.4,3I2)
31. 9 FORMAT(2I11)
32. 10 FORMAT (/,10X70HU/UE TO NODAL PT. GAMMA MOLECULAR
33. 1 /9X18HNORM. ETA AT WHICH13X40HWEIGHT
34. 2 /19X9HETA NORM.)
35. 8 FORMAT(3X1PE10.3,9X12,6X9E10.3/(30X9E10.3))
36. 11 FORMAT (/,5X70HU/UE TO NODAL PT.
37. 1 ETA VALUES /4X23HNORM. ETA AT WHICH
38. 2 /19X9HETA NORM.)
39. 12 FORMAT (/2X,15HNOSE RADIUS,FT ,1PE12,5,5X,16HCONE HALF ANGLE ,1PE1
40. 12.5,8H DEGREES)
41. 13 FORMAT (/,1X,23HTIME,SEC ,1P8E12.5/(24X,1P8E12.5))
42. 14 FORMAT (/,1X,16HTOTAL ENTHALPY, A6 ,1X ,1P8E12.5/(24X,1P8E12.5))
43. 18 FORMAT (/,1X,23HCASE ,1P8E12.5/(24X,1P8E12.5))
44. 15 FORMAT (/,1X,16HTOTAL PRESSURE, A6 ,1X ,1P8E12.5/(24X,1P8E12.5))
45. 16 FORMAT(A2,I2,I6)
46. 17 FORMAT (/,1X,17HINCID. RAD FLUX, A6 ,1P8E12.5/(24X,1P8E12.5))
47. 20 FORMAT(/,1X,56HSURFACE RECESSON - WALL TEMPERATURE RELATION FOR T
48. 1EFLON//5X,43HSURFACE RECESSON RATE, LB/SEC FT2 = EXP(((,1P E12.5,
49. 26H)*TW+(,1P E12.5,7H))*TW+(,1P E12.5,2H)),//5X,37HWHERE TW IS WALL
50. 3 TEMPERATURE IN DEG R)
51. 23 FORMAT (5X,39HTHE REFIT OPTION IS LIMITED TO 15 NODES)
52. C NOTE...KR(5)=4 FOR EQUIL,3 FOR EQUIL WITH ENTROPY LAYER, 1
53. C FOR NONEQUIL, AND 2 FOR NONEQUIL WITH ENTROPY LAYER...ROKAP=1 FOR
54. C PLANAR..(KR(6)=1 AND 3 FOR BLUNT AND SHARP, RESP) AND IS EQUAL TO
55. C DISTANCE FROM AXIS OF SYMMETRY TO BODY SURFACE FOR AXISYM..
56. C (KR(6)=0 AND 2 FOR BLUNT AND SHARP, RESPECTIVELY)... KR(7)=0 FOR
57. C MULTICOMPONENT B.L. AND=1 FOR HOMOGENEOUS B.L..IDISC=0 FOR NO
58. C DISCONTINUITY AND UNITY FOR DISC. IN ROKAP,FW, OR RHOWW
59. DATA MD(2)/6H /
60. CALL DATE (9,MD)
61. CALL TOD ( 18, MD)

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B09A, RECASE

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62. READ(KIN,1)KR,CASE
63. WRITE(KOUT,4)MD,CASE,KR
64. NSD(5)=0
65. NL=0
66. IF(KR(1).LE.1)GO TO 32
67. NSD(5)=1
68. NL=1
69. KR(1)=KR(1)-2
70. 32 CONTINUE
71. KEDGP = 0
72. IPLOT=0
73. IF(KR(13).GE.2) IPLOT=1
74. KR(13)=KR(13)-2*IPLOT
75. IUNIT=KR(13)
76. IF(KR(13).EQ.0) GO TO 100
77. UCD=1.0
78. UCE=1.0
79. UCL=1.0
80. UCM=1.0
81. UCP=1.0
82. UCR=1.0
83. UCS=1.0
84. UCT=1.0
85. UCV=1.0
86. KR(13)=0
87. 100 CONTINUE
88. RADFL(5)=UCL
89. RADFL(6)=22./7.
90. IF(KR(3)=2) 30,30,31
91. 31 KR(3) = KR(3)-3
92. KEDGP = 1
93. 30 CONTINUE
94. KQ(9)=0
95. ITDK=0
96. ITF(11)=KR(8)
97. KR(8)=0
98. IF(KR(6).NE.3) GO TO 110
99. ITDK=1
100. RADFL(5)=1.0
101. RADFL(6)=0.5
102. 110 CONTINUE
103. IF(KR(6).NE.7) GO TO 2402
104. KR(6)=8
105. ITDK=1
106. GO TO 2401
107. 2402 IF(KR(6).NE.6) GO TO 2401
108. KR(6) = 4
109. ITDK=1
110. 2401 IF(KR(6)=8) 245,240,245
111. 240 KQ(9)=1
112. KR(6)=4
113. GO TO 255
114. 245 IF(KR(6)=4) 255,255,250
115. 250 KQ(9)=1
116. KR(6)=KR(6)-5
117. 255 CONTINUE
118. IF(NL.EQ.0) GO TO 33
119. CALL MISCIN
120. NSPM1=NSP-1
121. NITEM=1
122. TIME(1)=-1.0
123. NTIME=1
124. IF (ITDK)3022,3022,34
125. 33 READ(KIN,24) NSP,KS

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B09A, RECASE

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126.      24 FORMAT(12,8X50I1)
127.      NSPM1=NSP=1
128.      NITEM=1
129.      TIME(1)=-1.0
130.      NTIME=1
131.      READ(KIN,24) NS,KR9
132.      IF(ITDK.EQ.0) GO TO 3021
133.      READ(KIN,5) S(1)
134.      34 CONTINUE
135.      CALL GEOM(S,ROKAP,PRE,KIN,NBT,NBT2,NS,PTET,ITF(12),GE,ITF(14),
136.      1 ITF(15))
137.      GO TO 3022
138.      3021 READ(KIN,5)(S(IS),IS=1,NS)
139.      3022 KAUXO=1
140.      IF(KR(14)=2) 303,303,302
141.      302 KAUXO=KR(14)-1
142.      KR(14)=KR(14)-3
143.      C COMPUTE INFORMATION NEEDED TO CONSIDER DISCONTINUITIES
144.      303 NDISC=0
145.      IDISC(1)=MAX0(IDISC(1),1)
146.      S(1)=ABS(S(1))
147.      IF(NS=1) 105,105,1021
148.      1021 DO 101 IS=2,NS
149.      IF(S(IS)) 103,101,101
150.      103 NDISC=NDISC+1
151.      S(IS)=-S(IS)
152.      IDISC(IS)=MAX0(IDISC(IS),1)
153.      101 CONTINUE
154.      105 CONTINUE
155.      IF(NL.NE.0)GO TO 605
156.      IF(KR(1)) 1051,1051,1052
157.      1052 READ(KIN,3) NETA,(ETA(I),I=1,NETA)
158.      READ(KIN,6) KAPPA,CBAR,KONRFT,NPOINT,RATLIM,KTURB,KAPPAT,NETAT
159.      IF(KONRFT.EQ.0) GO TO 1054
160.      KR10=KR(10)
161.      IF(NETA.GT.15) GO TO 1055
162.      GO TO 1056
163.      1055 WRITE(KOUT,23)
164.      STOP
165.      1056 READ(KIN,5)(F2FIX(I),I=1,NETA)
166.      IF(KTURB.EQ.0) GO TO 1054
167.      READ(KIN,5)(F2FIXT(I),I=1,NETAT)
168.      NPM1=NPOINT=1
169.      1054 CONTINUE
170.      1051 CONTINUE
171.      605 WRITE(KOUT,11)
172.      WRITE(KOUT,8) CBAR,KAPPA,(ETA(I),I=1,NETA)
173.      IF(NL.EQ.0)GO TO 35
174.      IF(KR(6).EQ.3)GO TO 37
175.      IF(ITDK) 2173,2173,2073
176.      35 CONTINUE
177.      406 IF(KR(6)=1) 203,203,204
178.      203 READ(KIN,5) CONE, RNOSE
179.      204 IF(IABS(KR(6)-2)-1) 207,208,207
180.      207 READ(KIN,5)RTM
181.      IF(ITDK.NE.0) GO TO 2073
182.      READ(KIN,5) (ROKAP(IS),IS=1,NS)
183.      2173 DO 2074 IS=2,NS
184.      DS=S(IS)-S(IS-1)
185.      DR=ROKAP(IS)-ROKAP(IS-1)
186.      2074 PTET(IS+10)=PTET(IS+9)+SQRT(DS*DS-DR*DR)
187.      2073 V=RTM*UCL
188.      DO 2072 IS=1,NS
189.      PTET(IS+10)=PTET(IS+10)*RTM

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B09A, RECASE

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190.      S(IS)=S(IS)*V
191. 2072 ROKAP(IS)=ROKAP(IS)*V
192.      IF (NS=1) 234,234,2071
193. 2071 IIS=2
194.      LNZ=1
195.      IF(ROKAP(1)) 223,226,226
196. 223 RADNO=ROKAP(1)
197.      WRITE (KOUT, 12) RADNO, CONE
198.      ROKAP(1)=0.
199.      DO 229 IS=1, NS
200.      IF(ROKAP(IS)) 224,224,225
201. 224 IF(KR(6)) 221,221,222
202. 222 ROKAP(IS)=S(IS)*SIN(RADNO/57.29578)
203.      GO TO 229
204. 221 ROKAP(IS)=RADNO*SIN(S(IS)/RADNO)
205. 229 CONTINUE
206.      GO TO 234
207. 225 IF (IS=NS) 2251,234,234
208. 2251 IIS=IIS+1
209.      LNZ=IS
210. 226 DO233 IS=IIS, NS
211.      IF(ROKAP(IS)) 233,233,227
212. 227 IF(IS=1-LNZ) 232,232,228
213. 228 LNZ=LNZ+1
214.      ROKAP(LNZ)=ROKAP(LNZ-1)+(S(LNZ)-S(LNZ-1))/(S(IS)-S(LNZ-1))*(ROKAP(
215. 1IS)-ROKAP(LNZ-1))
216.      GO TO 227
217. 232 LNZ=IS
218. 233 CONTINUE
219. 234 VKAP=1.
220.      GO TO 210
221. 208 READ(KIN,5) RTM
222. 37 V=RTM*UCL
223.      DO 209 IS=1, NS
224.      PTET(IS+10)=PTET(IS+10)*RTM
225.      S(IS)=S(IS)*V
226. 209 ROKAP(IS)=1.0
227.      VKAP=0.
228. 210 CONTINUE
229. 181 STEF = .481E-12
230.      IF (KR(9)=3) 197,193,198
231. 198 IF (KR(9)=4) 193,193,197
232. 197 DO 191 J=1, NS
233.      IF (KR9(J)=3) 191,193,192
234. 192 IF (KR9(J)=4) 191,193,191
235. 191 CONTINUE
236.      GO TO 199
237. 193 READ(KIN,21) (EMIV(I),HCHAR(I), HPYG(I), I=1,3)
238.      READ(KIN,22) (ASU(I),BSU(I), I=1,3)
239. 22 FORMAT(6A4)
240. 21 FORMAT(9E8,3)
241. 19 FORMAT(/1X39HQUASI-STEADY ENERGY BALANCE AT THE WALL//5X14HSURFACE
242. 1 NUMBER28X1H114X1H214X1H3/5X17HSURFACE EMITTANCE17X1P3E14.5/5X28HE
243. 2NTHALPY OF CHAR AT REF TEMPA6,3E15.5/5X,28HENTHALPY OF PYROLYSIS G
244. 3AS A6,3E15.5/5X27HEQUILIBRIUM SURFACE SPECIES 5X3(7X2A4))
245.      J=IUNIT+1
246.      WRITE(KOUT,19)EMIV,KA(J,1),HCHAR,KA(J,1),HPYG,
247. 1(ASU(I),BSU(I),I=1,3)
248.      DO 1931 I=1,3
249.      HCHAR(I)=HCHAR(I)*UCE
250. 1931 HPYG(I)=HPYG(I)*UCE
251. 199 IF (KR(9)=5) 194,196,196
252. 194 DO 195 J=1, NS
253.      K9R=KR9(J)

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B09A, RECASE

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254. IF (KR9(J)=5) 195,196,196
255. 195 CONTINUE
256. GO TO 182
257. 196 K9R=MAX0(K9R,KR(9))
258. IF (K9R.EQ.7) GO TO 200
259. READ(KIN,5) EMIST, HTEF, ADUM, BDUM, CDUM
260. WRITE (KOUT,20) ADUM, BDUM, CDUM
261. J=IUNIT+1
262. WRITE(KOUT,28) EMIST, HTEF, KA(J,1)
263. 28 FORMAT(/,5X,17HTEFLON PROPERTIES,/,10X,20HSURFACE EMITTANCE = ,
264. 1 1PE13.5,/,10X,28HENTHALPY OF VIRGIN TEFLON = ,1PE13.5,1H ,A6)
265. GO TO 182
266. 200 READ(KIN,5) EMIST, HTEF
267. J=IUNIT+1
268. WRITE(KOUT,29) EMIST, HTEF, KA(J,1)
269. 29 FORMAT(/,6X,21HADIBATIC WALL OPTION,/,
270. 17X,20HSURFACE EMITTANCE = ,E12.5,/,
271. 27X,34HINITIAL ENTHALPY OF TRANSPIRANT = ,1PE12.5,1H ,A6)
272. 182 IF (NL.NE.0) GO TO 2200
273. READ(KIN,5) PTET(1), PTET(2)
274. READ(KIN,5) (GE(IT), IT=1, NITEM)
275. READ(KIN,5) (RADFL(IT), IT=1, NITEM)
276. 2200 IF (TIME(1)) 2201, 220, 220
277. 2201 TIME(1)=TIME(1)
278. WRITE (KOUT,18) (TIME(I), I=1, NITEM)
279. TIME(1)=TIME(1)
280. GO TO 2202
281. 220 WRITE (KOUT,13) (TIME(I), I=1, NITEM)
282. 2202 J=IUNIT+1
283. WRITE(KOUT,14) KA(J,1), (GE(I), I=1, NITEM)
284. WRITE(KOUT,15) KA(J,2), (PTET(I), I=1, NITEM)
285. WRITE(KOUT,17) KA(J,11), (RADFL(I), I=1, NITEM)
286. PTET(1)=PTET(1)*UCP
287. GE(1)=GE(1)*UCE
288. RADFL(1)=RADFL(1)*UCR
289. RETURN
290. END

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B09B, GEOM

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1. SUBROUTINE GEOM(S,R,P,KIN,NBT,NBT2,NS,PTET,NTH,GE,IP,IU)
2. COMMON/BLQCOM/A(900)
3. COMMON/EDGCOM/ PE(40,1),PTE(40,1),SPE(6,40,1),DUES,
4. 1UE(40),RHOE(40),VMUE(40),TE(40),UEDGE,DUEGE,D2UEDG,VMWE,WE,C90
5. 2,DSIP(40),IDSIP,TTVC,TVC(40),HEA(40),SP(20),CS(20),CSPR(20),
6. 3CG(20),CGP(20),SREF,GEP,NEN,UINF,RHOINF,HINF,PINF
7. COMMON/EGPCOM/Z(2000)
8. COMMON/HISCOM/C1,C2,C3,C4,ALPHD,BETA,ZM(4,14),ZG(4,14),ZSP(4,14,6
9. 1),XI(40),HF(15,5),HG(15,3),HSP(15,3,6),HALPH,HUE,HMUE,HFW,OLX2
10. 2,C3M(40),BETAM(40),BETAV(40)
11. COMMON/NONCOM/UEI(500),DPDX(500),DUDX(500),DXDS(500),DUM(500)
12. COMMON/UNICOM/UCD,UCE,UCL,UCM,UCP,UCR,UCS,UCT,UCV,ITDK
13. 1,IUNIT,IPLT,KA(2,19)
14. DIMENSION S(40),R(40),P(40),NP(40),XITAB(500),YITAB(500)
15. 1,PITAB(500),VS(500),VA(500)
16. 2,PTET(50),GE(50)
17. EQUIVALENCE (XITAB(1),Z(1)),(YITAB(1),Z(501))
18. 1,(PITAB(1),Z(1001)),(VS(1),Z(1501)),(VA(1),A(1)),(NP(1),A(501))
19. NAMELIST/INPUT/N,NTH,NP,IP,IU,DPDX,DUDX,UEI,XITAB,YITAB,PITAB
20. WRITE(NBT)Z,A
21. ENDFILE NBT
22. REWIND NBT
23. J=1
24. READ(KIN,INPUT)
25. C N NO. OF STATIONS OF TDK DATA
26. C NP(IT) IDENTITY OF TDK STATIONS USED IN BLIMP
27. VS(1)=S(1)
28. IF(NP(1).NE.1) GO TO 201
29. J=2
30. R(1)=YITAB(1)
31. P(1)=PITAB(1)
32. PTET(11)=XITAB(1)
33. GE(11)=1.0
34. 201 DO 101 I=2,N
35. VX=XITAB(I)-XITAB(I-1)
36. VR=YITAB(I)-YITAB(I-1)
37. VS(I)=VS(I-1)+SQRT(VX*VX+VR*VR)
38. IF(J.NE.1) VA(I)=ATAN2(VR,VX)
39. IF(ABS(NP(J)).NE.1) GO TO 101
40. IF(J.NE.1) GO TO 103
41. DS=VS(I)-S(1)
42. DO 104 II=1,I
43. 104 VS(II)=VS(II)-DS
44. 103 S(J)=VS(I)
45. C NEG. S SETS FLAG FOR DISCONTINUITY
46. IF(NP(J).GT.0)GO TO 105
47. NP(J)=-NP(J)
48. S(J)=-S(J)
49. 105 R(J)=YITAB(I)
50. P(J)=PITAB(I)
51. PTET(J+10)=XITAB(I)
52. GE(J+10)=COS(VA(I))
53. C GE(11) TO GE(50) ARE USED TO CARRY COS(WALL ANGLE) FOR USE IN
54. C THRUST LOSS CALCULATION
55. C PTET(11) TO PTET(50) ARE USED TO CARRY XITAB FOR OUTPUT ONLY
56. J=J+1
57. 101 CONTINUE
58. IF(IU+IP.EQ.0) GO TO 111
59. IF(IP.EQ.1) CALL SLOPL(N,VS(1),PITAB(1),DPDX(1),DUM(1))
60. IF(IU.EQ.1) CALL SLOPL(N,VS(1),UEI(1),DUDX(1),DUM(1))
61. C NOTE THAT S AND P ARE NORMALIZED BY RTM AND PSTAG RESPEC. MUST UN

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B09B, GEOM

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62*      C      THIS LATER IN B07A.
63*      IF(IP.EQ.2.OR.IU.EQ.2) CALL SLOPL(N,VS(1),XITAB(1),DXDS(1),DUM(1))
64*      DO 110 L=1,NS
65*      IF(NP(L)
66*      C      PUT DPDS INTO BETAM AND DUDS INTO BETAV.
67*      IF(IP=1) 112,113,114
68*      113.BETAM(L)=DPDX(I)
69*      GO TO 112
70*      114.BETAM(L)=DPDX(I)*DXDS(I)
71*      112 IF(IU=1) 110,115,116
72*      115.BETAV(L)=DUDX(I)
73*      GO TO 117
74*      116.BETAV(L)=DUDX(I)*DXDS(I)
75*      117 UE(L)=UEI(I)*UCL
76*      C      UCL PUTS UE INTO BLIMP UNITS
77*      110 CONTINUE
78*      111 CONTINUE
79*      WRITE(NBT2)N,XITAB,YITAB,VS,PITAB,NP,VA
80*      ENDFILE NBT2
81*      REWIND NBT2
82*      READ(NBT2)Z,A
83*      REWIND NBT
84*      RETURN
85*      END

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B10A, HISTXI

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1. CR10A
2. SUBROUTINE HISTXI:
3. COMMON/EDGCOM/ PE(40, 1),PTE(40, 1),SPE( 6,40, 1),DUES,
4. 1UE(40),RHOE(40),VMUE(40),TE(40),UEDGE,DUEDGE,D2UEDG,VMWF,HE,C90
5. 2,DSIP(40),IDSIP,TTVC,TVCC(40)
6. COMMON/ETACOM/ETA(15),DETA(15),DSQ(14),DCU(14),B1(14),B2(14)
7. 1,LAR(123),BA1(43,18),BA2(30,15)
8. COMMON/HISCOM/C1,C2,C3,C4,ALPHD,BETA,ZM(4,14),ZG(4,14),ZSP(4,14, 6
9. 1),XI(40),HF(15,5),HG(15,3),HSP(15,3, 6),HALPH,HUE,HNUF,HFW,DLX2
10. 2,C3M(40),BETAM(40)
11. 3,BETAV(40)
12. COMMON/INTCOM/ KR(20),KIN,KOUT,MAT1I,MAT2I,MAT1J,MAT2J,NETA,I,IS,N
13. 19,IT,NTIME,NSP,NSPM1,NAM,NLEQ,NNLEQ,NRNL, ITS,KAPPA,CBAR,CASE(15)
14. 2,B(8), MWE,NON,KQ(10),ITEM,NITEM,KR17,NRT,NRT2,IDENT,KRQ(40)
15. 3,KAUXO,JTIME,JSPEC,MO(3),IU,ISH
16. COMMON/PRMCOM/TIME( 50),PRE(40),PTET( 50),GE( 50),S(40),ROKAP(40)
17. 1,RNOSE,VKAP,NDISC,IDISC(40),NSD(5),MSD(5),ITF( 50),IPRE,RADNO,CONE
18. 2,RADFL( 50),RADR(40),RAD(40),IRAD
19. COMMON/VARCOM/F(4,15),G(3,15),SP(3,15, 7),ALPH
20. COMMON/WALCOM/FW(40, 1),TW(40, 1),HW(40, 1),SPW( 6,40, 1)
21. 1,RHOVW(40, 1),FLUXJ( 3,40, 1),IHW,ITW,IFW,ISPW,IRHOVW,IFLUXJ
22. DIMENSION FD(4),GD(4),SPD(4)
23. C INITIALIZE AXIAL VARIATION TERMS
24. NUL=0
25. IF(18.NE.1)GO TO 399
26. 398 IF(IDISC(18).NE.2)GO TO 399
27. IS=IS+1
28. GO TO 398
29. 399 IF(KR(3).EQ.0)GO TO 154
30. IF(IU=2) 154,152,155
31. 152 DLX1=2.3
32. IF(KR(6).EQ.0)DLX1=3.5
33. IF(XI(ISH)) 157,157,155
34. 154 DZ=0.
35. D1=0.
36. D2=0.
37. IF(KR(2).LT.0) IS=-KR(2)
38. IF(KR(2).LT.0) IDISC(18)=1
39. M=NETA-1
40. DO 140 I=1,M
41. DO 140 J=1,4
42. ZM(J,I)=0.
43. 139 DO 140 K=NUL,NSPM1
44. ZSP(J,I,K)=0.
45. 140 CONTINUE
46. DO 141 I=1,NETA
47. DO 142 J=1,3
48. HF(I,J)=0.
49. 159 DO 142 K=NUL,NSPM1
50. HSP(I,J,K)=0.
51. 142 CONTINUE
52. HF(I,4)=0.
53. 141 HF(I,5)=0.
54. ALPHD=0.
55. HALPH=0.
56. DLX2=0.
57. GO TO 130
58. C COMPUTE TWO- OR THREE-POINT DIFFERENCE RELATIONS
59. 155 DLX1=ALOG(XI(18)/XI(ISH))
60. IF(IU.GT.2.AND.KR(3).EQ.2.AND.IDISC(18).NE.1) GO TO 121
61. 157 DZ=2./DLX1

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62.      D1=-DZ
63.      D2=0.
64.      GO TO 145
65.      121 DZ=DLX1+DLX2
66.      D1=-DZ/(DLX1+DLX2)*2.
67.      D2=DLX1/(DZ+DLX2)*2.
68.      DZ=-D1-D2
69.      145 DLX2=DLX1
70.      ALPHD=D1*ALPH+D2*HALPH
71.      HALPH=ALPH
72.      122 FD(3)=D1*F(4,1)+D2*HF(1,4)
73.      GD(3)=D1*G(3,1)+D2*HG(1,3)
74.      DO 147 I=2,NETA
75.      FD(1)=D1*F(2,I)+D2*HF(I,2)
76.      FD(2)=D1*F(3,I)+D2*HF(I,3)
77.      FD(4)=FD(3)
78.      FD(3)=D1*F(4,I)+D2*HF(I,4)
79.      CALL TAYLOR(DETA(I-1),FD(2),FD(1),ZH(1,I-1))
80.      GD(1)=D1*G(1,I)+D2*HG(I,1)
81.      GD(2)=D1*G(2,I)+D2*HG(I,2)
82.      GD(4)=GD(3)
83.      GD(3)=D1*G(3,I)+D2*HG(I,3)
84.      147 CALL TAYLOR(DETA(I-1),GD(2),GD(1),ZG(1,I-1))
85.      IF(NSPM1) 162,162,166
86.      166 DO 151 K=1,NSPM1
87.      SPD(3)=D1*SP(3,1,K)+D2*HSP(1,3,K)
88.      DO 151 I=2,NETA
89.      SPD(1)=D1*SP(1,I,K)+D2*HSP(I,1,K)
90.      SPD(2)=D1*SP(2,I,K)+D2*HSP(I,2,K)
91.      SPD(4)=SPD(3)
92.      SPD(3)=D1*SP(3,I,K)+D2*HSP(I,3,K)
93.      151 CALL TAYLOR (DETA(I-1),SPD(2),SPD(1),ZSP(1,I-1,K))
94.      C=---SAVE HISTORIC VALUES
95.      162 DO 164 I=1,NETA
96.      HF(I,4)=F(4,I)
97.      HF(I,5)=D1*F(1,I)+D2*HF(I,1)
98.      DO 164 J=1,3
99.      HF(I,J)=F(J,I)
100.      HG(I,J)=G(J,I)
101.      IF(NSPM1) 164,164,165
102.      165 DO 149 K=1,NSPM1
103.      149 HSP(I,J,K)=SP(J,I,K)
104.      164 CONTINUE
105.      C COMPUTE GROUPINGS WHICH DEPEND ON DZ
106.      130 C1=1.+DZ
107.      C2=-C1-DZ
108.      C3=C3H(IS)
109.      BETA=BETAM(IS)
110.      C4=BETAV(IS)+C1
111.      9904 FORMAT(6X12/8X1P10E10,3/8X8E10,3/(8X10E10,3))
112.      IF(KR(17)) 9905,9906,9905
113.      9905 CONTINUE
114.      WRITE(KOUT,9907)
115.      9907 FORMAT(2X27HDEBUG IS,DLX1,...ZH,ZG,HF,HG)
116.      WRITE(KOUT,9904) IS,DLX1,DLX2,DZ,D1,D2,ALPHD,HALPH,C1,C2,C4, FD
117.      1,GD,((ZH(I,J),J=1,6),I=1,4),((ZG(I,J),J=1,6),I=1,4),((HF(I,J),
118.      2 J=1,5),I=1,7),((HG(I,J),J=1,3),I=1,7)
119.      IF(NSPM1) 9906,9906,9908
120.      9908 WRITE(KOUT,9909)((ZSP(I,J,K),K=1,NSPM1),J=1,6),I=1,4),(((HSP(I,J,
121.      1 K),K=1,NSPM1),J=1,3),I=1,7)
122.      9909 FORMAT(2X13HDEBUG ZSP,HSP/(2X10E10,3))
123.      9906 CONTINUE
124.      RETURN
125.      END

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B11A, OUTPUT

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1.  CB11A
2.  SUBROUTINE OUTPUT
3.  DIMENSION CIJ( 60,1)
4.  COMMON/BLQCOM/ MDA( 60), MOB( 60),NSPEC,FR( 60,15),W(3),LEF( 8)
5.  1,LEF3( 8),PIEASE,LEF4( 8),L2,L3
6.  COMMON/COECON/ C5,C6,C7,C8,C9,C10,C11,C12,C13,C14,C15
7.  1,C16,C17,C18,C19,C20,C21,C22,C23,C24,C25,C26,C27,C28,C29,C30,C31,C
8.  232,C33,C34,C35,C36,C37,C38,C39,C40,C41,C42,C43,C44,C45,C46,C47,C48
9.  3,C49,C50,C51,C52,C53,C54,C55,C56,C57,C58,C59,C60,C61,C62,C63,C64,C
10. 465,C66,C67,C68,C69,C70,C71,C72,C73,C74,C75,C76,C77,C78,C79,CA0,C81
11. 5,C82,C83,C84,C85,C86,C87,C88
12. COMMON/COECON/ CK1( 6),CK2( 6),CK3( 6),CK4( 6),CK5( 6),CK6( 6)
13. 1,CK7( 6),CK8( 6),CK9( 6),CK10( 6),CK11( 6),CK12( 6),CK13( 6)
14. 2,CK14( 6),CK15( 6),CK16( 6),CK17( 6),CK18( 6),CK19( 6),CK20( 6)
15. 3,CK21( 6),CK22( 6),CKK1( 6, 6),CKK2( 6, 6),XM(5),XG(5),XSP(5, 7)
16. 4,CKK3( 6, 6)
17. COMMON/CRBCOM/HCARB,EMIS,STEF,ADUM,BDUM,CDUM,HTEF,HMAT,EMISC,EMIST
18. 1,HPG,ASU(3),BSU(3),HPYG(3),HCHAR(3),EMIV(3),KS(40),ISU
19. COMMON/EDGCOM/ PE(40, 1),PTE(40, 1),SPE( 6,40, 1),DUES,
20. 1UE(40),RHOE(40),VMUE(40),TE(40),UEDGE,DUEDGE,DZUEDG,VMWE,HE,C90
21. 2,DSIP(40),IDSIP,TTVC,TVCC(40),HEA(40),SF(20),CS(20),CSPR(20),
22. 3 CG(20),CGP(20),SREF,GEP,NEN
23. COMMON/EPSCOM/ELCON,YAP,CLNUM,SCY,PRT,RED,DVS,RHOVS,PI,PIM,CL,
24. 1 EPSA(15),EP81,EL(15),DPI(15,2),DEPC,TREF,RETR
25. COMMON/EGPCOM/RB(60,3),RC(60,3),RD(60,3),RE(60,3),RF(60,3),RG(60,3)
26. 1,TU(60,3),FF(60),FFA,IPC(60),ATA(8),ATB(8),ATC(8),WAT(8),RA(60,3)
27. 3,
28. 2 KAT( 8),IR( 8),IZ,KZ(10),LAMI( 60),P,Z,TK( 8, 8),VN( 60),
29. 3 VNU( 60, 8),ITFF,KR2,HCH,NCV,WM,WTM( 60),YYY( 60),YW( 60),GG( 60)
30. 4 ,TQ( 8, 8),EPOVRK,SIGMA,BASMDL
31. COMMON/EQTCOM/SIP,HIP,EEL,EENL,FLIQ,CPF,IRE,IER,AA,IITS,IN,IL,IIT,
32. 1 MODE,HMELT,SMELT,TMAX,TMIN,MELT,SUMN,SUML,WS,WSS,BX,ISP2,ISPG,
33. 2 ISP,KKJ,SVA,SVB,SVC,SVD,SUMC,FFF,CMF,EP,RV,IFCJC,WTG,WTL,JC,HMG,
34. 3 CCPG,TMIN,TMAX,L7,L8,IB( 9),EB( 8),EBL( 8),A(14,14),BB(14),
35. 4 IP( 60),ALP( 8),FNU( 8),GAMH( 8),GAMF( 8),SLAM( 8),DY( 60),RVS,
36. 5 CP( 60),HH( 60),SB( 60),TC( 60),VLNK( 60),E( 60),PNUS( 8),
37. 6 BC( 8),BLNK( 8),BY( 8),IBC( 8),BE( 8),JZ( 4)
38. COMMON/ETACOM/ETA(15),DETA(15),DSQ(14),DCU(14),B1(14),B2(14)
39. 1,LAR(123),BA1(43,18),BA2(30,15)
40. COMMON/FLXCOM/DELQW,DELJW( 6),WALLQ,WALLJ( 6),GW,VJKW( 7),TPWALL
41. COMMON/HISCOM/C1,C2,C3,C4,ALPHD,BETA,ZM(4,14),ZG(4,14),ZSP(4,14, 6
42. 1 ),XI(40),HF(15,5),HG(15,3),HSP(15,3, 6),HALPH,HUE,WHUE,HFW,DLX2
43. 2,C3M(40),BETAM(40)
44. 3,BETAV(40)
45. COMMON/INTCOM/ KR(20),KIN,KOUT,MAT1I,MAT2I,MAT1J,MAT2J,NETA,I,IS,N
46. 19,IT,NTIME,NSP,NSPM1,NAH,NLEQ,NNLEQ,NRNL, ITS,KAPPA,CBAR,CASE(15)
47. 2,B(8), MWE,NON,KQ(10),ITEM,NITEM,KR17,NBT,NBT2,IDENT,KR9(40)
48. 3,KAUXO,JTIME,JSPEC,MD(3)
49. 4,IDUM(2),KONRFT
50. COMMON/RFTCOM/ F2FIX(15),DUM5(3),RATLIM,UKAPPA(15)
51. *,KTURB,KAPPAT,NETAT,F2FIXT(15),NETAL,KAPPAL
52. COMMON/OUTCOM/Y(15),RES,DELST,THENGY,THMMQ,CH,BLOW,SHEAR,CF,SHAPE
53. 1,CM( 7),THELEM( 7)
54. COMMON/PRMCOM/TIME( 50),PRE(40),PTET( 50),GE( 50),S(40),ROKAP(40)
55. 1,RNOSE,VKAP,NDISC,DISC(40),NSD(5),MSD(5),ITF( 50),IPRE,RADNO,CONE
56. 2,RADFL( 50),RADR(40),RADS(40),IRAD
57. COMMON/PRRCOM/PR(15),T(15),RHO(15),SC(15),CAPC(15),OR(15),H(15)
58. 1,CPBAR(15),VMW(15),PHIK(15, 6),DRHOH,DRHOK( 6),ZK( 6),DZKH( 6), D
59. 2MU3K( 6),DMU4K( 6),DTK( 6),DPHIKH( 6),DPRK( 6),DSCK( 6),DCAPCK( 6)
60. 3,DHTILK( 6),DQRK( 6),DCPBK( 6),DCPTK( 6),DMUI2K( 6),DZKK( 6, 6)
61. 4,DPHIKK( 6, 6), DMU4H,DMU3H,DHTILH,VMUI2,CT,CTR,CPTTL,HTIL

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62. 5,VMU3,OTH,DCAPCH,DPRH,DSCH,DQRH,DCPBH,DCPTH,DMU12H,VMU(15), RHOP
63. 6(15),PHIKP(15),HP,TP,ZKP( 6),VMU3P,VMU4P,HTILP,CRHC(14),GMR(15)
64. COMMON/TEMCOM/SPDUM( 6),DER(40),DUMM1(15),SLOPE(15),REDUM(15)
65. 1,SDUM1(40),SDUM2(40),FWDUM(40),XICON(40),FWCON(40),FWINIT( 1)
66. 2,XIINIT( 1),DUDS( 40)
67. COMMON/TURB/ STURB,DELCON,DCLNUM,TURPR(15)
68. COMMON/VARCOM/F(4,15),G(3,15),SP(3,15, 7),ALPH
69. COMMON/WALCOM/FW(40, 1),TW(40, 1),HW(40, 1),SPW( 6,40, 1)
70. 1,RHOVW(40, 1),FLUXJ( 3,40, 1),IHW,ITW,IFW,ISPW,IRHOVW,IFLUXJ
71. COMMON/UNICOM/UCD,UCE,UCL,UCM,UCP,UCR,UCS,UCT,UCV,ITDK
72. 1 ,IUNIT,IPL0T,KA(2,19)
73. C AP IS USED FOR THE OUTPUT OF PLOT INFORMATION
74. DIMENSION AP(1)
75. EQUIVALENCE(AP(1),FWDUM(1))
76. EQUIVALENCE (VNU,CIJ)
77. 1 FORMAT(/7X,80HALPHA RADIUS PRESSURE EDGE VEL. BETAP B
78. 1ETAV HEAT FLUXES== A6,/
79. 217X,A6,5X,A6,4X,A6,21X,37HDIFFUSIONAL TOT ENTH RERAD. QCOND,/
80. 35X,1P11E10.3)
81. 2 FORMAT(/8X,4HWALL,7X,12HMASS FLUXES ,A6,18X,32HELEMENTAL MASS DIFF
82. 1USIVE FLUXES ,A6,4H FOR / 5X, 50H
83. 2SHEAR MECHANICAL PYROL CHAR TOTAL GAS 8(1X2A4,1X))
84. 19 FORMAT(6X,A6,4X,15HREMOVAL GAS)
85. 3 FORMAT(5X1P12E10.3)
86. 18 FORMAT(/6X109HMMOM TRANS HEAT TRANS BLOWING PARAMETERS EL
87. 1EMENTAL MASS TRANSFER COEFFICIENTS, /5X110H
88. 2COEFF, COEFF, (NORM. BY RHOE*UE*ST) FOR CM, FOR
89. 3 /4X51H CF/2
90. 4 ST NO. PYROL GAS CHAR TOTAL GAS
91. 4 8(1X2A4,1X))
92. 4 FORMAT(5X70H MOMENTUM DISPLACE. EFFECTIVE ENTHALPY REYNOLDS MAS
93. 18 THICKNESS FOR ,/
94. 35X49H THICKNESS,THICKNESS, BODY THICKNESS, NUMBER ,/
95. 45X44H THETA DELSTAR DISPLACE. LAMBDA PER ,A6,8(1X2A4,1X))
96. 120 FORMAT(7X,4(A6,4X),10X,7(A6,4X))
97. 20 FORMAT(5X1P11E10.3)
98. 5 FORMAT(/2X17HNODAL INFORMATION)
99. 6 FORMAT(8X,103HETA DISTANCE F U/UE FPP SHE
100. 1AR G, TOTAL GP GPP STATIC TEMP,/,
101. 28X,16H FROM WALL,42X, 8HENTHALPY,22X,8HENTHALPY,/,
102. 317X,A6,34X,A6,5X,A6,,4X,A6,4X,A6,4X,A6,3X,A6)
103. 7 FORMAT(6X,86HDISTANCE DENSITY VISCOSITY SPECIFIC THERMAL PR
104. 1ANDTL MODIFIED MOLECULAR MACH,4X,19HRHOSQ*EPS TURBULENT,/,
105. 25X,88HFROM WALL RHO MU HEAT COND. NUMBER
106. 3 SCHMIDT WEIGHT NUMBER,3X,20H/RHOE*MUE PRANDTL NO ,/
107. 47X,A6,4X,A6,5X,A6,3X,A6,5X,A6,13X6HNUMBER)
108. 8 FORMAT (/2X78HELEMENTAL FRACTIONS AND THEIR FIRST AND SECOND DERIV
109. 1ATIVES WITH RESPECT TO ETA,/)
110. 12 FORMAT(/)
111. 13 FORMAT(/,41X20HDISTANCE FROM WALL, A6,/(15X1P10E10.3/20X1P9E10.3))
112. 14 FORMAT(6X,2A4,1X,1P10E10.3/20X,1P9E10.3/(15X,1P10E10.3/20X,1P
113. 1 9E10.3))
114. 15 FORMAT (15X,1P10E10.3/20X1P9E10.3)
115. 16 FORMAT (/2X14HMOLE FRACTIONS,/)
116. 17 FORMAT(/23H SURFACE SPECIES IS 2A4)
117. 110 FORMAT(A2,3I2,1P6E12.5)
118. 112 FORMAT(A2,3I2,1P6E12.5/(8X,1P6E12.5))
119. 113 FORMAT (A2,6X,18A4/(20A4))
120. DATA IBLANK/2H /
121. TVCF(X)=(SQRT(AMAX1(0.,1.+2.*COSOR*X))-1.)/COSOR
122. 107 IF(KR(9)=2) 301,301,302
123. 102 RHOVW(15,IT)= C1*F(1,1) +HF(1,5)
124. 101 C89=-C3*ALPH*VMUE(15)
125. DUM1=-1./C3

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B11A, OUTPUT

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126.      DUM2=RHOVW(IS,IT)/C3
127.      IF (UE(IS)-1.0) 3012,3011,3012
128. 3011 UE(IS)=0.
129. 3012 CONTINUE
130.      WALLQ=-WALLQ/C3
131.      DER(3)=WALLQ-DUM2*G(1,1)
132.      WALLJ(NSP)=0.
133.      IF (NSPM1) 3051,3051,3050
134. 3050 DO 305 K=1,NSPM1
135.      WALLJ(K)=VJKW(K)
136.      WALLJ(NSP)=WALLJ(NSP)-WALLJ(K)
137. 3051 CONTINUE
138.      DER(1)=W(2)/C3
139.      DER(2)=W(3)/C3
140.      VMECH=DER(1)+DER(2)-DUM2
141.      DUM4=VMECH*100.
142.      IF (DUM4-DUM2) 1901,190,190
143. 1901 VMECH=0.
144.      IF (ABS(BETA)=-.0001) 303,304,304
145.      303 BETA=0.
146.      304 Y(1)=0.
147.      SHFAC=UE(IS)/(C3*ALPH*ALPH*32.174)
148.      DUDS(1)=(CAPC(1)+EPSA(1))*F(3,1)*SHFAC
149.      DO 182 I=2,NETA
150.      DUDS(I)=(CAPC(I)+EPSA(I))*F(3,I)*SHFAC
151.      182 Y(I)=Y(I-1)+C89*CRHO(I-1)
152.      QCOND=VMUE(IS)/PR(1)*CAPC(1)/C89+G(2,1)+DUM2*G(1,1)
153.      SHEAR=DUDS(1)
154.      IF (KR(9)-3) 2101,2102,2102
155. 2101 EMIS=0.
156. 2102 RERAD=(.481E-12)*(T(1))*4.*EMIS
157.      QDIFU=CAPC(1)/ALPH*CPHAR(1)/PR(1)*TPWALL/C3
158.      DER(11)=ALPH
159.      DER(12)=ROKAP(IS)/RADFL(5)
160.      DER(13)=PE(IS,IT)/UCP
161.      DER(14)=UE(IS)/UCL
162.      DX=UE(IS)*UE(IS)*RHOE(IS)/32.174
163.      YR=DER(12)*RADFL(6)
164.      DER(15)=BETA
165.      IF (ABS(BETAV(IS)),LE,0.0001) BETAV(IS)=0.0
166.      DER(16)=BETAV(IS)
167.      DER(17)=WALLQ/UCR
168.      DER(18)=DER(3)/UCR
169.      AP(1)=DER(18)
170.      DER(19)=RERAD/UCR
171.      DER(20)=QDIFU/UCR
172.      HEAT=DER(18)*YR
173.      IF (KR(9).LE,2) GO TO 2104
174.      HEAT=0.0
175.      IF (RADS(IS).LT,-1.0E-04) HEAT=-RADS(IS)/UCR
176. 2104 CONTINUE
177.      IF (IS.NE,1) GO TO 2103
178.      AREA=0.0
179.      IF (ITDK.EQ,0) GE(11)=1.0
180.      GO TO 2106
181. 2103 AREA=(S(IS)-S(IS-1))/UCL
182.      IF (ITF(13).NE,0) AREA=0.0
183.      ITF(13)=0
184.      IF (ITDK.EQ,1) GO TO 2106
185.      GE(IS+10)=ATAN2((ROKAP(IS)-ROKAP(IS-1)),(UCL*(PTET(IS+10)-
186.      1PTET(IS+9))))
187.      GE(IS+10)=COS(GE(IS+10))
188. 2106 CONTINUE
189.      L=IUNIT+1

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B11A, OUTPUT

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190. WRITE(KOUT,1)KA(L,11),KA(L,9),KA(L,2),KA(L,7),(DER(J),J=11,20)
191. 212 DUM1=RHON(ETA)/VMU(ETA)*UE(15)/ALPH*F(2,ETA)
192. CH= WALLG / (G(1,ETA)-G(1,1))
193. CF=CAPC(1)/ALPH*VMUE(15)/C89*F(3,1)
194. 213 WRITE(KOUT,2)KA(L,12),KA(L,12),(ATA(K),ATB(K),K=1,NSP)
195. WRITE(KOUT,19)KA(L,17)
196. DUM4=ALPH*ALPH
197. DO 203 I=1,NETA
198. SP(1,I,NSP)=1.0
199. SP(2,I,NSP)=0.
200. 203 SP(3,I,NSP)=0.
201. IF (NSPM1) 2021,2021,2020
202. 2020 DO 202 K=1,NSPM1
203. DO 202 I=1,NETA
204. SP(1,I,NSP)=SP(1,I,NSP)-SP(1,I,K)
205. SP(2,I,K)=SP(2,I,K)/ALPH
206. SP(2,I,NSP)=SP(2,I,NSP)-SP(2,I,K)
207. SP(3,I,K)=SP(3,I,K)/DUM4
208. 202 SP(3,I,NSP)=SP(3,I,NSP)-SP(3,I,K)
209. 2021 CONTINUE
210. XSP(5,NSP)=F(1,ETA)-F(1,1)
211. IF(NSPM1) 2138,2138,2135
212. 2138 VJKW(1)=0.
213. CM(1)=0.
214. THELEM(1)=0.
215. GO TO 2137
216. 2135 DO 2136 I=1,NSPM1
217. 2136 XSP(5,NSP)=XSP(5,NSP)-XSP(5,I)
218. DO 2131 I=1,NSP
219. VJKW(I)=0.
220. DO 2132 K=1,NSP
221. 2132 VJKW(I)=VJKW(I)-WALLJ(K)/WTM(K)*CIJ(I,K)
222. 2131 VJKW(I)=VJKW(I)*WAT(I)
223. 2137 CONTINUE
224. UCMF=UCE/UCR
225. DER(11)=SHEAR/UCS
226. AP(2)=DER(11)
227. DER(12)=VMECH*UCMF
228. DER(13)=DER(1)*UCMF
229. DER(14)=DER(2)*UCMF
230. DER(15)=DUM2*UCMF
231. AP(3)=DER(15)
232. DO 2237 I=1,NSP
233. 2237 DER(I+15)=VJKW(I)*UCMF
234. NSJ=15+NSP
235. WRITE(KOUT,3)(DER(J),J=11,NSJ)
236. 214 RES=DUM1*S(18)
237. ADR=C89/F(2,ETA)*RHOE(15)/RHO(ETA)
238. DUM3=ADR*(F(1,ETA)-F(1,1))
239. DELST=Y(ETA)-DUM3
240. REDELS=DUM1*DELST
241. THENGY=(DUM3*(G(1,ETA)-ADR*XG(5)))/(G(1,ETA)-G(1,1))
242. RETHEN=DUM1*THENGY
243. THMOM=DUM3-ADR*XM(5)/F(2,ETA)
244. RETHMO=DUM1*THMOM
245. DELBO=Y(ETA)-ADR*F(1,ETA)
246. THCOND=CPBAR(1)/RHO(1)*RHOE(15)/G(2,1)*C89*(T(ETA)-T(1))
247. BLOW=DUM2/CH
248. 207 BLOWPG=DER(1)/CH
249. BLOWCH=DER(2)/CH
250. IF(NSPM1) 2074,2074,2070
251. 2070 DO 2071 I=1,NSP
252. THELEM(1)=0.
253. CM(1)=0.

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B11A, OUTPUT

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254.      DUZ=0.
255.      DO 2072 K=1,NSP
256.      DUZ=DUZ+(DUM3*SP(1,NETA,K)-C89/ALPH*XSP(5,K))/WTM(K)*CIJ(1,K)
257.      THELEM(I)=THELEM(I)+(SP(1,NETA,K)-SP(1,1,K))/WTM(K)*CIJ(1,K)
258.      IF (THELEM(I)) 2073,2071,2073
259.      2073 CM(I)=VJKW(I)/(THELEM(I)*WAT(I))
260.      THELEM(I)=DUZ/THELEM(I)
261.      2071 CONTINUE
262.      2074 IF(KQ(9)) 2075,2078,2075
263.      2075 COSQR=-TVCC(IS)/VMUE(IS)*0.5/C3*FLOAT(KQ(9))
264.      DO 2076 I=1,NETA
265.      Y(I)=TVCF(Y(I))
266.      2076 DUDS(I)=DUDS(I)*(1.+COSQR*Y(I))
267.      DELST=TVCF(DELST)
268.      DELBD=TVCF(DELBD)
269.      THMMOM=TVCF(THMMOM)
270.      THENGY=TVCF(THENGY)
271.      DO 2077 K=1,NSP
272.      2077 THELEM(K)=TVCF(THELEM(K))
273.      2078 CONTINUE
274.      WRITE(KOUT,18) (ATA(K),ATB(K),K=1,NSP)
275.      DER(10)=RHOE(IS)*UE(IS)
276.      DER(11)=CF/DER(10)
277.      DER(12)=CH/DER(10)
278.      DER(13)=BLOWPG
279.      DER(14)=BLOWCH
280.      DER(15)=BLOW
281.      AP(4)=DER(11)
282.      AP(5)=DER(12)
283.      AP(6)=DER(15)
284.      DO 2139 I=1,NSP
285.      2139 DER(I+15)=CM(I)/DER(10)
286.      NSJ=15+NSP
287.      WRITE(KOUT,3) (DER(J),J=11,NSJ)
288.      WRITE(KOUT,12)
289.      WRITE(KOUT,4) KA(L,3),(ATA(K),ATB(K),K=1,NSP)
290.      GE(9)=THMMOM/UCL
291.      TIME(IS+10)=DELBD/UCL
292.      AP(7)=GE(9)
293.      AP(8)=TIME(IS+10)
294.      NSJ=NSP+13
295.      DER(11)=DELST/UCL
296.      DER(12)=THENGY/UCL
297.      DER(13)=DUM1*UCL
298.      DO 2140 I=1,NSP
299.      2140 DER(I+13)=THELEM(I)/UCL
300.      I=NSP+4
301.      WRITE(KOUT,120) (KA(L,9),J=1,I)
302.      WRITE(KOUT,20) GE(9),DER(11),TIME(IS+10),(DER(K),K=12,NSJ)
303.      DF=PE(IS,1)*DELBD*2116./(DX*THMMOM)
304.      DF=2.0*YR*DX*GE(9)*GE(IS+10)*(1.-DF)/UCS
305.      WRITE(KOUT,21) KA(L,13),KA(L,18),KA(L,19),KA(L,10),KA(L,10)
306.      21 FORMAT(/6X,72HTOTAL HEAT THRUST TOTAL ACCELERATION INV
307.      1ISCID TOTAL
308.      2/,7X,72HTO WALL LOSS WALL AREA PARAMETER-K MASS IN BL
309.      3 MASS IN BL ,/ 2X,3(6X,A6),13X,2(6X,A6))
310.      RADFL(8)=RADFL(8)+(ROKAP(IS-1)+ROKAP(IS))*RADFL(6)*AREA/RADFL(5)
311.      RADFL(9)=RADFL(9)+(RADFL(7)+HEAT)*AREA
312.      RADFL(7)=HEAT
313.      C *** RADFL(7) IS USED TO SAVE PI*ROKAP(I)*QWALL
314.      C *** RADFL(8) IS USED TO SAVE THE ACCUMULATED WALL AREA
315.      C *** RADFL(9) IS USED TO SAVE THE TOTAL HEAT TO THE WALL
316.      ACCP=RETAV(IS)*VMUE(IS)*VMUE(IS)*ROKAP(IS)*ROKAP(IS)/2./XI(IS)
317.      VMDOTB=SQRT(2.*XI(IS))*2.*RADFL(6)/UCH

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31A.      VMDDTI=VMDOTB*F(1,NETA)
319.      VMDOTB=VMDOTB*(F(1,NETA)-F(1,1))
320.      WRITE(KOUT,22)RADFL(9),DF,RADFL(8),ACCP,VMDDTI,VMDOTB
321.      22 FORMAT(3X,1P6E12.3)
322.      209 WRITE(KOUT,5)
323.      WRITE(KOUT,6)KA(L,9),KA(L,17),(KA(L,1),I=1,4),KA(L,5)
324.      DO 183 I=1,NETA
325.      C      COMPUTE TRUE VALUES OF F(I,J) AND ETA
326.      Y(I)=Y(I)/UCL
327.      DER(1)=F(1,I)
328.      DER(2)=F(2,I)/ALPH
329.      DER(3)=F(3,I)/DUM4
330.      DER(4)=DUDS(I)/UCS
331.      DER(5)=G(1,I)/UCE
332.      DER(6)=G(2,I)/(UCE*ALPH)
333.      DER(7)=G(3,I)/(DUM4*UCE)
334.      DER(8)=H(I)/UCE
335.      DER(9)=T(I)/UCT
336.      AP(I+10)=DER(2)
337.      AP(I+25)=DER(8)
338.      AP(I+40)=DER(9)
339.      183 WRITE(KOUT,3)ETA(I),Y(I),(DER(J),J=1,9)
340.      WRITE(KOUT,12)
341.      WRITE(KOUT,7)KA(L,9),KA(L,8),KA(L,14),KA(L,15),KA(L,16)
342.      DO 184 I=1,NETA
343.      COND=CPBAR(I)/PR(I)*VMU(I)
344.      GMR(I)=ABS(GMR(I))
345.      ACH=F(2,I)/ALPH*UE(IS)/SQRT(GMR(I)/VMW(I)*T(I)*49732.)
346.      DER(2)=RHO(I)/UCD
347.      DER(3)=VMU(I)/UCV
348.      DER(4)=CPBAR(I)*UCT/UCE
349.      DER(5)=DER(4)*DER(3)/PR(I)
350.      AP(I+55)=ACH
351.      AP(I+70)=DER(2)
352.      AP(I+85)=DER(3)
353.      AP(I+100)=DER(4)
354.      184 WRITE(KOUT,3)Y(I),(DER(J),J=2,5),PR(I),SC(I),VMW(I),ACH,EP5A(I)
355.      1 ,TURPR(I)
356.      IF (KR(7).EQ.1) GO TO 193
357.      WRITE(KOUT,13) KA(L,9),(Y(I),I=1,NETA)
358.      WRITE(KOUT, 8)
359.      DO 201 K=1,NSP
360.      WRITE (KOUT,14) MOA(K),MOB(K),(SP(1,I,K),I=1,NETA)
361.      WRITE (KOUT,15)(SP(2,I,K),I=1,NETA)
362.      201 WRITE (KOUT,15)(SP(3,I,K),I=1,NETA)
363.      IF (NSPM1) 2041,2041,2040
364.      2040 DO 204 K=1,NSPM1
365.      DO 204 I=1,NETA
366.      SP(2,I,K)=SP(2,I,K)*ALPH
367.      204 SP(3,I,K)=SP(3,I,K)*DUM4
368.      2041 CONTINUE
369.      WRITE (KOUT,16)
370.      DO 196 J=1,NSPEC
371.      196 WRITE(KOUT,14) MOA(J),MOB(J),(FR(J,I),I=1,NETA)
372.      IF(KR(9).EQ.4) WRITE(KOUT,17) MOA(ISU),MOB(ISU)
373.      193 CONTINUE
374.      C      OUTPUT FOR PLOT
375.      IF(IPL0T.NE.1)GO TO 194
376.      KPLT=HSD(2)
377.      WRITE(KPLT)IS,NETA,
378.      1      (AP(I),I=1,8),RADFL(9),DF,RADFL(8),ACCP,VMDDTI,VMDOTB
379.      2 ,Y,(AP(I),I=11,115),EP5A
380.      194 CONTINUE
381.      325 WALLQ=-WALLQ+C3

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B11A, OUTPUT

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382.      IF (NON.LT.0) RETURN
383.      NETAM1=NETA-1
384.      KAPAM1=KAPPA-1
385.      KAPAP1=KAPPA+1
386.      NETAL=NETA
387.      KAPPAL=KAPPA
388.      IF (KONRFT.EQ.0) RETURN
389.      IF (KQ(10).GT.0.AND.KTURB.GT.0) GO TO 4019
390.      IF (IS.NE.1.OR.ITEM.NE.1) GO TO 4002
391.      GO TO 4021
392. 4019 KTURB=-1
393.      Y(I)=Y(I)*UCL
394.      NETAL=NETA
395.      KAPPAL=KAPPA
396.      NETA=NETAT
397.      KAPPA=KAPPAT
398.      NETAM1=NETA-1
399.      KAPAM1=KAPPA-1
400.      KAPAP1=KAPPA+1
401.      DO 4020 I=1,NETA
402. 4020 F2FIX(I)=F2FIXT(I)
403.      DO 4018 I=NETAL,NETAM1
404. 4018 T(I+1)=-1.0
405. 4021 IF (KR(5).EQ.0) GO TO 4002
406.      DO 4000 I=1,KAPAM1
407. 4000 UKAPPA(I)=F2FIX(I)/F2FIX(KAPPA)
408.      UKAPPA(KAPPA)=1.0
409.      FDIFF=F2FIX(NETA)-F2FIX(KAPPA)
410.      DO 4001 I=KAPAP1,NETAM1
411. 4001 UKAPPA(I)=(F2FIX(I)-F2FIX(KAPPA))/FDIFF
412.      UKAPPA(NETA)=1.0
413. 4002 CONTINUE
414.      IF (KTURB+1) 4022,4023,4022
415. 4023 KTURB=0
416.      GO TO 327
417. 4022 CONTINUE
418.      IF (IS.EQ.NS) GO TO 326
419.      IF (KR(5).EQ.0) GO TO 4012
420.      RATKAP=F(2,KAPPA)/ALPH
421.      DO 4010 I=1,KAPAM1
422. 4010 F2FIX(I)=UKAPPA(I)*RATKAP
423.      F2FIX(KAPPA)=F(2,KAPPA)/ALPH
424.      FDIFF=F(2,NETA)-F(2,KAPPA)
425.      DO 4011 I=KAPAP1,NETAM1
426. 4011 F2FIX(I)=(F(2,KAPPA)+FDIFF*UKAPPA(I))/ALPH
427.      F2FIX(NETA)=F(2,NETA)/ALPH
428. 4012 CONTINUE
429.      IF (IS.EQ.1) GO TO 327
430.      DO 326 I=2,NETAM1
431.      M=I
432.      DIF=F(2,I)-F2FIX(I)*ALPH
433.      IF (DIF.LT.0.0) M=I+1
434.      DEL=F(2,M)-F(2,M-1)
435.      RAT=ABS(DIF/DEL)
436.      IF (RAT.GT.RATLIM) GO TO 327
437. 326 CONTINUE
438.      KONRFT=1
439.      RETURN
440. 327 CALL REFIT
441.      KONRFT=2
442.      RETURN
443.      END

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1.  CB11B
2.  SUBROUTINE ROCOUT
3.  C**** IN ORDER TO SAVE SPACE AND USE EXISTING COMMON BLOCKS THE
4.  C**** QUANTITIES OF INTEREST TO THIS SUBROUTINE ARE PLACED ON DRUM OR IN
5.  C**** THE UNUSED PORTION OF THE MULTIPLE CASE VARIABLES. THE
6.  C**** FOLLOWING LIST DESCRIBES THIS USAGE:
7.  C**** XITAB(N) = DRUM = AXIAL COORDINATE
8.  C**** YITAB(N) = DRUM = RADIUS
9.  C**** VS(N) = DRUM = STREAMWISE LENGTH
10. C**** THESE QUANTITIES ARE NORMALIZED BY RTM
11. C**** RTM = PTET(9) = NORMALIZING FACTOR IN METERS (THROAT RADIUS)
12. C**** PITAB(N) = DRUM = PRESSURE RATIO
13. C**** VA(N) = DRUM = WALL ANGLE
14. C**** N = DRUM = NUMBER OF STATIONS OF XITAB, YITAB, PITAB, VS, VA
15. C**** NP(15) = DRUM = IDENTITY OF THE STATIONS USED AS BLIMP
16. C**** SOLUTION STATIONS
17. C**** NS = NUMBER OF BLIMP SOLUTION STATIONS
18. C**** DELBD = TIME(15+10) = BODY DISPLACEMENT AT EACH BLIMP STATION
19. C**** (METERS)
20. C**** X(15) = PTET(15+10) = AXIAL COORDINATE OF BLIMP STATION IN METERS
21. C**** ITF(11) = FLAG SET EQUAL TO KR(8) TO CALL THE CARD PUNCH OPTION
22. C**** AND LIST CORRECTED RADIUS OPTION.
23. C**** ITF(12) = STATION NO. OF THROAT
24. C**** GE(15+10) COS OF WALL ANGLE FOR BLIMP STATIONS
25. COMMON/BLQCOM/A(900)
26. COMMON/EDGCOM/ PE(40, 1), PTE(40, 1), SPE( 6, 40, 1), DUES,
27. 1UE(40), RHOE(40), VMUE(40), TE(40), UEDGE, DUEGE, D2UEGE, VMWE, HE, C90
28. 2, DSIP(40), IDSIP, TVVC, TVCC(40), HEA(40), SF(20), CS(20), CSPR(20),
29. 3CG(20), CGP(20), SREF, GEP, NEN, UINF, RHOINF, HINF, PINF
30. COMMON/EGPCOM/Z(2000)
31. COMMON/INTCOM/ KR(20), KIN, KOUT, MAT1I, MAT2I, MAT1J, MAT2J, NETA, I, IS, N
32. 1S, IT, NTIME, NSP, NSPM1, NAM, NLEG, NNLEG, NRNL, ITS, KAPPA, CBAR, CASE(15)
33. 2, B(8), MWE, NQN, KG(10), ITEM, NITEM, KR17, NBT, NBT2, IDENT, KR9(40)
34. 3, KAUXO, JTIME, JSPEC, MD(3), IU, ISH
35. COMMON/PRMCOM/TIME( 50), PRE(40), PTET( 50), GE( 50), S(40), ROKAP(40)
36. 1, RNOSE, VKAP, NDISC, IDISC(40), NSD(5), MSD(5), ITF( 50), IPRE, RADNO, CONE
37. 2, RADFL(50), RADR(40), RAD9(40), IRAD
38. COMMON/UNICOM/UCD, UCE, UCL, UCM, UCP, UCR, UCS, UCT, UCV, ITDK
39. 1, IUNIT, IPLOT, KA(2, 19)
40. DIMENSION NP(40), XITAB(500), YITAB(500)
41. 1, PITAB(500), VS(500), VA(500)
42. EQUIVALENCE (XITAB(1), Z(1)), (YITAB(1), Z(501))
43. 1, (PITAB(1), Z(1001)), (VS(1), Z(1501)), (VA(1), A(1)), (NP(1), A(801))
44. EQUIVALENCE (PTET(9), RTM)
45. 1 FORMAT(1H1, 10X, 20HSTATION SUMMARY FOR , 15A4, //)
46. 3 FORMAT(15H 0.0 , 0.0 SEND)
47. 4 FORMAT(10H PW(1))= , 4(E14.8, 1H, ), //, (10X, 4(E14.8, 1H, ), 10X))
48. 5 FORMAT(31X, 23HNEW CONTOUR INFORMATION, //)
49. 6 FORMAT(29X, 22HINPUT INVISCID CONTOUR, 9X, 18HINPUT WALL CONTOUR, /
50. 126X, 58HNEW WALL CONTOUR=NORM. BY NEW INVISCID CONTOUR=NORM. BY/
51. 223X, 14HTHROAT RADIUS=E12.5, A6, 15H THROAT RADIUS=E12.5, A6, /
52. 335H STATION DISPLACEMENT AXIAL, 9X, 6HRAIDIAL, 10X, 5HAXIAL,
53. 49X, 6HRAIDIAL, /
54. 53X, 3HNO, , 4X10HTHICKNESS A6, 4(3X, 10HCOORDINATE, 2X))
55. 7 FORMAT(16, 3X, 1P5E15.5)
56. KPCH=MSD(1)
57. C** HEADING SETUP
58. WRITE(KOUT, 1) CASE
59. C** IF NO NAMELIST INPUT -CORRECT ONLY BLIMP STATIONS
60. IF(ITDK, EQ, 0) GO TO 110
61. READ(NBT2) N, XITAB, YITAB, VS, PITAB, NP, VA

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B11B, ROCOUT

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62.      N=NP(NS)
63.      PTET(10)=0.0
64.      TIME(10)=0.0
65.      C** CALCULATE CORRECTED BODY CONTOUR FOR TDK
66.      DO 200 IS=1,NS
67.      SL=(TIME(IS+10)-TIME(IS+9))/(PTET(IS+10)-PTET(IS+9))
68.      XL= PTET(IS+9)/RTM
69.      YL= TIME(IS+9)/RTM
70.      IF(IS.NE.1)GO TO 201
71.      IA=1
72.      GO TO 202
73.      201 IA=NP(IS-1)+1
74.      202 IB=NP(IS)
75.      C** CALCULATE CORRECTIONS TO CONTOUR
76.      C** ORIGINAL CONTOUR= XITAB,YITAB, WALL ANGLE=VA
77.      DO 203 I=IA,IB
78.      DELC= SL*(XITAB(I)-XL)+YL
79.      VS(I)=DELC*RTM
80.      XC=DELC*SIN(VA(I))
81.      RC=DELC*COS(VA(I))
82.      VA(I)= XITAB(I)+XC
83.      XITAB(I)=XITAB(I)-XC
84.      PITAB(I)= YITAB(I)-RC
85.      203 YITAB(I)= YITAB(I)+RC
86.      200 CONTINUE
87.      C** NEW WALL CONTOUR= (XITAB,YITAB)
88.      C** NEW INVISCID CONTOUR= (VA,PITAB)
89.      C** DISPLACEMENT THICK, -VS
90.      NT=ITF(12)
91.      C** FOR PUNCH OF NEW BODY CONTOUR (INVISCID INPUT)
92.      C** FIND NEW MIN RADIUS=
93.      C** LOOK BACK FROM THROAT
94.      302 IF(YITAB(NT).LE.YITAB(NT-1)) GO TO 310
95.      NT=NT-1
96.      IF(NT.GT.0)GO TO 302
97.      WRITE(KOUT,21)
98.      21 FORMAT(5X,22HPROGRAM STOP IN ROCOUT )
99.      STOP
100.     310 IF(NT.NE.ITF(12)) GO TO 314
101.     C LOOK AHEAD OF THROAT
102.     312 IF(YITAB(NT).LE.YITAB(NT+1)) GO TO 314
103.     NT=NT+1
104.     IF(NT.LT.N) GO TO 312
105.     WRITE(KOUT,21)
106.     STOP
107.     C** NEW THROAT RADIUS -MUST ADJUST XITAB AND RENORMALIZE
108.     314 RTW=YITAB(NT)
109.     NT=NT
110.     NT=ITF(12)
111.     C** FOR PUNCH OF INVISCID CONTOUR (BODY INPUT)
112.     C** LOOK BACK FROM THROAT
113.     301 IF(PITAB(NT).LE.PITAB(NT-1)) GO TO 320
114.     NT=NT-1
115.     IF(NT.GT.0)GO TO 301
116.     WRITE(KOUT,21)
117.     STOP
118.     320 IF(NT.NE.ITF(12)) GO TO 324
119.     C** LOOK AHEAD OF THROAT
120.     322 IF(PITAB(NT).LE.PITAB(NT+1)) GO TO 324
121.     NT=NT+1
122.     IF(NT.LT.N)GO TO 322
123.     WRITE(KOUT,21)
124.     STOP
125.     324 RTI=PITAB(NT)

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B11B, ROCOUT

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126. C** ADJUST COORDS. AND RENORM.
127. DO 326 J=1,N
128. YITAB(J)=YITAB(J)/RTW
129. XITAB(J)=(XITAB(J)-XITAB(NTW))/RTW
130. PITAB(J)=PITAB(J)/RTI
131. 326 VA(J)=(VA(J)-VA(NT))/RTI
132. RTW=RTW*RTM
133. RTI=RTI*RTM
134. IF(ITF(11)=2) 401,315,303
135. C** OUTPUT OF NEW BODY CONTOUR
136. 315 WRITE(KPCH,4) (YITAB(I),XITAB(I),I=1,N)
137. GO TO 402
138. C** OUTPUT OF INVISCID CONTOUR
139. 401 WRITE(KPCH,4) (PITAB(I),VA(I),I=1,N)
140. 402 WRITE(KPCH,3)
141. GO TO 303
142. C** CALCULATE NEW BODY CONTOUR FOR BLIMP STATIONS ONLY
143. 110 DO 112 I=1,NS
144. XITAB(I)=PTET(I+10)/RTM
145. ROKAP(I)=ROKAP(I)/UCL/RTM
146. VS(I)=TIME(I+10)/RTM
147. RC=VS(I)*GE(I+10)
148. XC=VS(I)*SQRT(1.-GE(I+10)*GE(I+10))
149. VA(I)=XITAB(I)+XC
150. VS(I)=VS(I)*RTM
151. PITAB(I)=ROKAP(I)-RC
152. XITAB(I)=XITAB(I)-XC
153. 112 YITAB(I)=ROKAP(I)+RC
154. RTW=RTM
155. RTI=RTM
156. N=NS
157. C** LIST OF NEW CONTOUR POINTS
158. 303 WRITE(KOUT,5)
159. J = IUNIT + 1
160. WRITE(KOUT,6)RTW,KA(J,9),RTI,KA(J,9),KA(J,9)
161. WRITE(KOUT,7)(I,VS(I),XITAB(I),YITAB(I),VA(I),PITAB(I),I=1,N)
162. 900 RETURN
163. END

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1.  CB12B
2.  SUBROUTINE IMONE
3.  COMMON/COECON/ C5,C6,C7,C8,C9,C10,C11,C12,C13,C14,C15
4.  1,C16,C17,C18,C19,C20,C21,C22,C23,C24,C25,C26,C27,C28,C29,C30,C31,C
5.  232,C33,C34,C35,C36,C37,C38,C39,C40,C41,C42,C43,C44,C45,C46,C47,C48
6.  3,C49,C50,C51,C52,C53,C54,C55,C56,C57,C58,C59,C60,C61,C62,C63,C64,C
7.  465,C66,C67,C68,C69,C70,C71,C72,C73,C74,C75,C76,C77,C78,C79,C80,C81
8.  5,C82,C83,C84,C85,C86,C87,C88
9.  COMMON/COECON/ CK1( 6),CK2( 6),CK3( 6),CK4( 6),CK5( 6),CK6( 6)
10. 1,CK7( 6),CK8( 6),CK9( 6),CK10( 6),CK11( 6),CK12( 6),CK13( 6)
11. 2,CK14( 6),CK15( 6),CK16( 6),CK17( 6),CK18( 6),CK19( 6),CK20( 6)
12. 3,CK21( 6),CK22( 6),CKK1( 6, 6),CKK2( 6, 6),XM(5),XG(5),XSP(5, 7)
13. 4,CKK3( 6, 6)
14. COMMON/ERRCOM/ FLE( 43),GLE(30),SPLE(30, 6),ELA(253),FLEM,GLEM
15. 1,SPLEM( 6),ELM(14),ELMM,IFLM,IGLM,ISPLM( 6),NELM,ILMM,DFL(43)
16. 2,DGL(30),DSPL(30, 6),FNLE(18),GNLE(15),SPNLE(15, 6),ENL(123)
17. 3,FNLEM,GNLEM,SPNLEM( 6), ENLMM,IFNLM,IGNLM,ISPNLM( 6)
18. 4,NENLM,INLMM,DFNL(18),DGNL(15),DSPNL(15, 6),DRNL( 8)
19. COMMON/ETACOM/ ETA(15),DETA(15),DSQ(14),DCU(14),B1(14),B2(14)
20. 1,LAR(123),BA1(43,18),BA2(30,15)
21. COMMON/HISCOM/ C1,C2,C3,C4,ALPHD,BETA,ZM(4,14),ZG(4,14),ZSP(4,14, 6
22. 1 ),XI(40),HF(15,5),HG(15,3),HSP(15,3, 6),HALPH,HUE,HWUE,HFW,NLX2
23. 2,C3M(40),BETAM(40)
24. COMMON/INTCOM/ KR(20),KIN,KOUT,MAT1I,MAT2I,MAT1J,MAT2J,NETA,I,IS,N
25. 1S,IT,NTIME,NSP,NSPM1,NAM,NLEQ,NNLEQ,NRNL, ITS,KAPPA,CBAR,CASE(15)
26. 2,B(8), MWE,NON,KQ(10),ITEM,NITEM,KR17,NBT,NBT2,IDENT,KR9(40)
27. 3,KAUXO,JTIME,JSPEC,MD(3)
28. COMMON/NONCOM/ AM(123,123),DVNL(123),TCW,
29. 1VLNKH,OLPH( 7),DLPK( 6, 7),DTHW,DTKW( 6),FLUXJB( 7)
30. COMMON/PRPCOM/ PR(15),T(15),RHO(15),SC(15),CAPC(15),QR(15),H(15)
31. 1,CPBAR(15),VMW(15),PHIK(15, 6),DRHOM,DRHOK( 6),ZK( 6),DZKH( 6), D
32. 2MU3K( 6),DMU4K( 6),DTK( 6),DPHIKH( 6),DPRK( 6),DSCK( 6),DCAPCK( 6)
33. 3,DHTILK( 6),DGRK( 6),DCPBK( 6),DCPTK( 6),DMU12K( 6),DZKK( 6, 6)
34. 4,DPHIKK( 6, 6), DMU4H,DMU3H,DHTILH,VMU12,CT,CTR,CPTIL,HTIL
35. 5,VMU3,DTH,DCAPCH,DPRH,DSCH,DGRH,DCPBH,DCPTH,DMU12H,VMU(15), RHOP
36. 6(15),PHIKP(15),HP,TP,ZKP( 6),VMU3P,VMU4P,HTILP,CRHO(14),GMR(15)
37. COMMON/VARCOM/ F(4,15),G(3,15),SP(3,15, 7),ALPH
38. C EVALUATE GROUPINGS WHICH CONTRIBUTE TO (I-1) PORTION OF COEFFS
39. C VARIABLES WITH DIMENSION (NETA=1)
40. 4000 CRHO(I-1)=C26*DETA(I-1)*(1.-C53/6.0*DETA(I-1))
41. C63=C6*CRHO(I-1)
42. IF (I-2) 4001,4002,4001
43. 4002 XM(5)=0.
44. XG(5)=0.
45. IF (NSPM1) 401,401,4003
46. 4003 DO 4004 K=1,NSPM1
47. 4004 XSP(5,K)=0.
48. 4001 CONTINUE
49. C EVALUATE XM,XG,AND XSP (WHICH CONTRIBUTE TO ERRORS AND TO COEFFS
50. C AT (I) AND AT (I-1))
51. 401 CALL TAYLOR (DETA(I-1),F(2,I-1),F(2,I),XM)
52. CALL TAYLOR (DETA(I-1),G(1,I-1),G(1,I),XG)
53. IF(NSPM1)403,403,404
54. 404 DO 414 K=1,NSPM1
55. 414 CALL TAYLOR (DETA(I-1),SP(1,I-1,K),SP(1,I,K),XSP(1,K))
56. C EVAL PORTION OF NLE DEPENDENT ON XM,... AND GROUPINGS EVAL AT I-1
57. 403 C72=F(2,I)*XM(1) +F(3,I)*XM(2) +F(4,I)*XM(3) +F(4,I-1)*XM(4)
58. XM(5)=XM(5)+C72
59. ENL(I+3)=-(-C83+C63/2.-C9*C72-2.*(F(2,I)*ZM(1,I-1)+F(3,I)*ZM(2
60. 1,I-1)+F(4,I)*ZM(3,I-1)+F(4,I-1)*ZM(4,I-1)))
61. DUM1=F(2,I)*XG(1)+F(3,I)*XG(2)+F(4,I)*XG(3)+F(4,I-1)*XG(4)

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62.      XG(5)=XG(5)+DUM1
63.      MPI=MAT1J+I-1
64.      ENL(MPI)=-C84+C2*DUM1-(F(2,I)+ZG(1,I-1)+F(3,I)+ZG(2,I-1)+F(4,I)+
65.      1ZG(
66.      23,I-1)+F(4,I-1)+ZG(4,I-1))-(G(1,I)+ZM(1,I-1)+G(2,I)+ZM(2,I-1)+G(3,
67.      3I)+ZM(3,I-1)+G(3,I-1)+ZM(4,I-1)))
68.      IF(NSPM1)405,405,406
69.      406 DO 407 K=1,NSPM1
70.      MPI=MPI+MAT2J-1
71.      DUM1=F(2,I)*XSP(1,K)+F(3,I)*XSP(2,K)+F(4,I)*XSP(3,K)+F(4,I-1)* XSP
72.      1(4,K)
73.      XSP(5,K)=XSP(5,K)+DUM1
74.      ENL(MPI)=-CK22(K)+C2*DUM1-(F(2,I)+ZSP(1,I-1,K)+F(
75.      23,I)+ZSP(2,I-1,K)+F(4,I)+ZSP(3,I-1,K)+F(4,I-1)+ZSP(4,I-1,K))-(SP(1
76.      3,I,K)+ZM(1,I-1)+SP(2,I,K)+ZM(2,I-1)+SP(3,I,K)+ZM(3,I-1)+SP(3,I-1,K
77.      4)+ZM(4,I-1)))
78.      407 CONTINUE
79.      C EVAL PORTION OF ORIG COEFFS OF AM DEPENDENT UPON PARAM EVAL AT I-1
80.      C*** ESTABLISH INDICES ON VARIABLES
81.      405 NUL=0
82.      IFN=I-2
83.      IFP=I-2
84.      IFPP=NETA+I-3
85.      IFPPP=IFPP+NETA
86.      ISPN=I
87.      ISPP=I-1
88.      ISPPP=IFPP+2
89.      C*** MOMENTUM EQUATION CORRECTION COEFFICIENTS
90.      AM(I+3,1)=-C81+C87*DETA(I-1)
91.      AM(I+3,IFP)=-C74+C86*DETA(I-1)
92.      IF(I-2) 410,410,415
93.      410 AM(I+3,2)=-C73
94.      AM(I+3,3)=-C12
95.      GO TO 420
96.      415 CALL LIAD(-1,I+3,IFN,-C73)
97.      CALL LIAD(-1,I+3,IFPP,-C12)
98.      420 CALL LIAD(-1,I+3, IFPPP,-2.*(C9 * XM(4)+ZM(4,I-1)))
99.      LPI=ISPN+MAT1J
100.      DO 450 K=NUL, NSPM1
101.      IF(K) 425,425,430
102.      425 DUM1=C88*DETA(I-1)-C75
103.      DUM2=0.
104.      GO TO 435
105.      430 DUM1=CK13(K)*DETA(I-1)-CK17(K)
106.      DUM2=0.
107.      435 AM(I+3,LPI)=DUM1
108.      IF(I-2) 440,440,445
109.      440 AM(I+3,LPI-1) = DUM2
110.      GO TO 450
111.      445 CALL LIAD(K,I+3, ISPP, DUM2)
112.      450 LPI=LPI+MAT2J
113.      C*** ENERGY AND SPECIES EQUATIONS
114.      MPJ=MAT1J+I-1
115.      MQJ=116
116.      DO 535 K=NUL, NSPM1
117.      MQJ=MQJ+1
118.      C* * ALF, F, FP, FPP, FPP ERROR DERIVITIVES ARE DUM1 TO DUM5. DUM6 TO
119.      C* * DUM8 ARE FLUX DERIVITIVES FOR ALF, FP, FPP.
120.      IF(K) 455,455,460
121.      C= - ENERGY EQUATIONS
122.      455 DUM1=-C82
123.      DUM2=-C76
124.      DUM3=-C77
125.      DUM4=-C78

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126.      DUM6=C82
127.      DUM7=C77
128.      DUM8=C78
129.      GO TO 465
130. C - - SPECIES EQUATIONS
131.      460 DUM1=-(CK21(K)+2.*C56 *CK15(K))
132.          DUM2=-CK18(K)
133.          DUM3=-CK19(K)+CK15(K)
134.          DUM4=-CK20(K)+C10*CK14(K)
135.          DUM6=CK21(K)
136.          DUM7=CK19(K)
137.          DUM8=CK20(K)
138.      465 DUM5=C2 *XSP(4,K)-ZSP(4,I-1,K)
139.          AM(MPJ,1)=DUM1
140.          AM(MPJ,IFP)= DUM3
141.          IF(I-2) 470,470,472
142.      470 AM(MPJ,2)=DUM2
143.          AM(MPJ,3)= DUM4
144.          AM(MQJ,1)=DUM6
145.          AM(MQJ,IFP)=DUM7
146.          AM(MQJ,3)=DUM8
147.          GO TO 475
148.      472 CALL LIAD(-1,MPJ,IFN,DUM2)
149.          CALL LIAD(-1, MPJ, IFPP, DUM4)
150.      475 CALL LIAD(-1,MPJ, IFPPP, DUM5)
151.          LPI= ISPN+MAT1J
152.          DO 530 KK=NUL, NSPM1
153. C * * DUM1/DUM4 AND DUM2/DUM5 ARE ERROR/FLUX DERIVATIVES WRT G OR SP AND
154. C * * GP OR SPP, RESP.
155.          IF(K+KK) 480,480,485
156. C - - ENERGY EQ. G VARIABLES
157.      480 DUM2=-C80
158.          DUM4=C43
159.          DUM5=C80
160.          GO TO 515
161.      485 IF(K) 490,490,495
162. C - - ENERGY EQUATION, SP VARIABLES
163.      490 DUM1=-CK1(KK)
164.          DUM2=-CK2(KK)
165.          DUM4=-DUM1
166.          DUM5=-DUM2
167.          GO TO 508
168.      495 IF(KK) 500,500,505
169. C - - SPECIES EQS., G VARIABLES
170.      500 DUM1=-CK9(K)
171.          DUM2=-CK5(K) + CK14(K)
172.          DUM4=CK9(K)
173.          DUM5=CK5(K)
174.          GO TO 508
175. C - - SPECIES EQS., SP VARIABLES
176.      505 DUM1=-CKK2(K,KK)
177.          DUM2=-CKK1(K,KK)+B1(I-1)*CKK3(K,KK)
178.          DUM4=-DUM1
179.          DUM5=CKK1(K,KK)
180.          IF(K=KK) 508,515,508
181.      515 DUM1=-DUM4-C14
182.      508 AM(MPJ,LPI)=DUM1
183.          IF(I-2) 510,510,525
184.      510 AM(MPJ, LPI-1)= DUM2
185.      520 AM(MQJ,LPI)=DUM4
186.          AM(MQJ,LPI-1)=DUM5
187.          GO TO 530
188.      525 CALL LIAD(KK,MPJ, ISPP, DUM2)
189.      530 LPI=LPI+MAT2J
190.          CALL LIAD(K,MPJ,ISPPP,C2 *XM(4)-ZM(4,I-1))
191.      535 MPJ=MPJ+MAT2J-1
192.          RETURN
193.          END

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1.  CBI3A
2.  SUBROUTINE IONLY
3.  DIMENSION CK23( 6),CK24( 6),CK25( 6),CK26( 6)
4.  COMMON/COECON/ C5,C6,C7,C8,C9,C10,C11,C12,C13,C14,C15
5.  1,C16,C17,C18,C19,C20,C21,C22,C23,C24,C25,C26,C27,C28,C29,C30,C31,C
6.  232,C33,C34,C35,C36,C37,C38,C39,C40,C41,C42,C43,C44,C45,C46,C47,C48
7.  3,C49,C50,C51,C52,C53,C54,C55,C56,C57,C58,C59,C60,C61,C62,C63,C64,C
8.  465,C66,C67,C68,C69,C70,C71,C72,C73,C74,C75,C76,C77,C78,C79,C80,C81
9.  5,C82,C83,C84,C85,C86,C87,C88
10. COMMON/COECON/ CK1( 6),CK2( 6),CK3( 6),CK4( 6),CK5( 6),CK6( 6)
11. 1,CK7( 6),CK8( 6),CK9( 6),CK10( 6),CK11( 6),CK12( 6),CK13( 6)
12. 2,CK14( 6),CK15( 6),CK16( 6),CK17( 6),CK18( 6),CK19( 6),CK20( 6)
13. 3,CK21( 6),CK22( 6),CKK1( 6, 6),CKK2( 6, 6),XM(5),XG(5),XSP(5, 7)
14. 4,CKK3( 6, 6)
15. COMMON/ERRCOM/FLE( 43),GLE(30),SPLE(30, 6),ELA(253),FLEM,GLEM
16. 1,SPLEM( 6),ELM(14),ELMM,IFLM,IGLM,ISPLM( 6),NELM,IILMM,DFL(43)
17. 2,DGL(30),DSPL(30, 6),FNLE(18),GNLE(15),SPNLE(15, 6),ENL(123)
18. 3,FNLEM,GNLEM,SPNLEM( 6), ENLMM,IFNLM,IGNLM,ISPNLM( 6)
19. 4,NENLM,INLMM,DFNL(18),DGNL(15),DSPNL(15, 6),DRNL( 8)
20. COMMON/ETACOM/ETA(15),DETA(15),DSQ(14),DCU(14),B1(14),B2(14)
21. 1,LAR(123),BA1(43,18),BA2(30,15)
22. COMMON/HISCOM/C1,C2,C3,C4,ALPHD,BETA,ZM(4,14),ZG(4,14),ZSP(4,14, 6
23. 1 ),XI(40),HF(15,5),HG(15,3),HSP(15,3, 6),HALPH,HUE,HHUE,HFW,DLX2
24. 2,C3M(40),BETAM(40)
25. COMMON/INTCOM/ KR(20),KIN,KOUT,MAT1I,MAT2I,MAT1J,MAT2J,NETA,I,IS,N
26. 18,IT,NTIME,NSP,NSPM1,NAM,NLEQ,NNLEQ,NRNL,ITS,KAPPA,CBAR,CASE(15)
27. 2,B(8), MWE,NON,KQ(10),ITEM,NITEM,KR17,NBT,NBT2,IDENT,KR9(40)
28. 3,KAUXO,JTIME,JSPEC,MD(3)
29. COMMON/NONCOM/AM(123,123),DVNL(123),TCW,
30. 1VLNKH,DLPH( 7),OLPK( 6, 7),DTHW,DTKW( 6),FLUXJB( 7)
31. COMMON/PRPCOM/PR(15),T(15),RHO(15),SC(15),CAPC(15),OR(15),W(15)
32. 1,CPBAR(15),VMW(15),PHIK(15, 6),DRHOH,DRHOK( 6),ZK( 6),DZKH( 6), D
33. 2MU3K( 6),DMU4K( 6),DTK( 6),DPHIKH( 6),DPRK( 6),DSCK( 6),DCAPCK( 6)
34. 3,DHTILK( 6),DGRK( 6),DCPBK( 6),DCPTK( 6),DMU12K( 6),DZKK( 6, 6)
35. 4,DPHIKK( 6, 6), DMU4H,DMU3H,DHTILH,VMU12,CT,CTR,CPTTL,HTIL
36. 5,VMU3,DTH,DCAPCH,DPRH,DSCH,DGRH,DCPBH,DCPTH,DMU12H,VMU(15), RHO
37. 6(15),PHIKP(15),HP,TP,ZKP( 6),VMU3P,VMU4P,HTILP,CRHO(14),GMR(15)
38. COMMON/VARCOM/F(4,15),G(3,15),SP(3,15, 7),ALPH
39. DIMENSION CYM(3),CXM(3),CYSP(3)
40. C ADD CONTRIBUTIONS OF I TO NONLINEAR ERRORS
41. C EVALUATE GROUPINGS WHICH ARE USED ONLY AT I (NOT AT I-1)
42. 400 CRHO1= C26*DETA(I-1)*(1.+C53/6.0*DETA(I-1))
43. C89=C6*CRHO1
44. CRHO(I-1)=(CRHO(I-1)+CRHO1)/2.
45. ENL(I+3)=ENL(I+3)-(C83+C89/2.)
46. MPI=MAT1J+I-1
47. ENL(MPI)=ENL(MPI)-C84
48. IF(NSPM1)403,403,402
49. 402 DO 436 K=1,NSPM1
50. MPI=MPI+MAT2J-1
51. ENL(MPI) =ENL(MPI) -(CK22(K)-(PHIK(I,K)*DETA(I-1)-PHIKP(K)*B2(I-1)
52. 1-CK16(K)))
53. 436 CONTINUE
54. 404 DO 467 K=1,NSPM1
55. CK23(K)=B2(I-1)*DPHIKH(K)
56. CK24(K)=C13*CK23(K)
57. CK25(K)=DETA(I-1)*DPHIKH(K)
58. 467 CK26(K)=C10*CK25(K)
59. C EVAL PORTION OF ORIG COEFFS OF AM DEPENDENT UPON PARAM EVAL AT I
60. C*** ESTABLISH INDICES FOR VARIABLES
61. 403 NUL=0

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62.      IFN=I-1
63.      IFP=I+3
64.      IFPP=NETA+I-2
65.      IFPPP=IFPP+NETA
66.      ISPN=I+1
67.      ISPP=I
68.      ISPPP=IFPP+2
69.      DO 405 L=1,3
70.      CYM(L)=C2*XM(L)-ZM(L,I-1)
71.      405 CXM(L)=-(C9*XM(L) + ZM(L,I-1))*2.
72.      C**** MOMENTUM EQUATION
73.      AM(I+3,1)=AM(I+3,1)+C81-C5*C8+C72+C87*DETA(I-1)
74.      AM(I+3,IFP)=AM(I+3,IFP)+C74+C86*DETA(I-1)+CXM(1)
75.      CALL LIAD(-1,I+3,IFN,C73)
76.      CALL LIAD(-1,I+3,IFPP,C12+CXM(2))
77.      CALL LIAD(-1,I+3,IFPPP,CXM(3))
78.      LPI=ISPN+MAT1J
79.      DO 425 K=NUL, NSPM1
80.      IF(K) 410,410,415
81.      410 DUM1=C75+C88*DETA(I-1)
82.      DUM2=0.
83.      GO TO 416
84.      415 DUM1=CK13(K)*DETA(I-1)+CK17(K)
85.      DUM2=0.
86.      416 IF(I-NETA) 420,417,420
87.      417 CALL LIAD(K,I+3,1,DUM1)
88.      GO TO 421
89.      420 AM(I+3,LPI)=AM(I+3,LPI)+DUM1
90.      421 CALL LIAD(K,I+3,ISPP,DUM2)
91.      425 LPI=LPI+MAT2J
92.      C**** ENERGY AND SPECIES EQUATIONS
93.      MPJ=MAT1J+I-1
94.      DO 490 K=NUL, NSPM1
95.      DO 428 L=1,3
96.      428 CYSP(L)=C2*XSP(L,K)-ZSP(L,I-1,K)
97.      C * * ALF, F, FP, FPP, FPPP ERROR DERIVATIVES ARE DUM1 TO DUM5.
98.      IF(K) 430,430,435
99.      C - - ENERGY EQ.
100.      430 DUM1=C82
101.      DUM2=C76
102.      DUM3=C77+CYSP(1)
103.      DUM4=C78+CYSP(2)
104.      GO TO 440
105.      C - - SPECIES EQS.
106.      435 DUM1=CK21(K) +C56 *(CK26(K)-2. *CK24(K))
107.      DUM2=CK18(K)
108.      DUM3=CK19(K) + CK24(K)-CK26(K)+CYSP(1)
109.      DUM4=C10*(CK5(K)+CK23(K)) + CYSP(2)
110.      440 DUM5=CYSP(3)
111.      AM(MPJ,1)=AM(MPJ,1) + DUM1
112.      AM(MPJ,IFP)=AM(MPJ,IFP) + DUM3
113.      CALL LIAD(-1,MPJ,IFN,DUM2)
114.      CALL LIAD(-1,MPJ,IFPP,DUM4)
115.      CALL LIAD(-1,MPJ,IFPPP,DUM5)
116.      LPI=ISPN+MAT1J
117.      DO 485 KK=NUL,NSPM1
118.      C * * DUM1 AND DUM2 ARE ERROR DERIVATIVES WRT G OR SP AND GP OR SPP
119.      IF(K+KK) 445,445,450
120.      C - - ENERGY EQ., G VARIABLES
121.      445 DUM1=C43
122.      DUM2=C80
123.      GO TO 475
124.      450 IF(K) 455,455,460
125.      C - - ENERGY EQ., SP VARIABLES

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813B, IONLY

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126.      455 DUM1=CK1(KK)
127.      DUM2=CK2(KK)
128.      GO TO 480
129.      460 IF(KK) 465,465,470
130.      C - - SPECIES EQS., G VARIABLES
131.      465 DUM1= CK9(K)-CK25(K)
132.      DUM2=CK5(K)+CK23(K)
133.      GO TO 480
134.      C - - SPECIES EQS., SPECIES VARIABLES
135.      470 DUM1=CKK2(K,KK)-DPHIKK(K,KK)*DETA(I-1)
136.      DUM2=CKK1(K,KK)+B2(I-1) * DPHIKK(K,KK)
137.      IF(K=KK) 480,475,480
138.      475 DUM1=DUM1+CYM(1)+C14
139.      DUM2=DUM2+CYM(2)
140.      480 IF(I=NETA) 483,482,483
141.      482 CALL LIAD(KK,MPJ,1,DUM1)
142.      GO TO 484
143.      483 AM(MPJ,LPI)=AM(MPJ,LPI)+DUM1
144.      484 CALL LIAD(KK,MPJ,ISPP,DUM2)
145.      485 LPI= LPI+MAT2J
146.      CALL LIAD(K,MPJ,ISPPP, CYM(3))
147.      490 MPJ=MPJ+MAT2J-1
148.      RETURN
149.      END

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B14A, STATE

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1. CB14A
2. SUBROUTINE STATE
3. COMMON/EDGCOM/ PE(40, 1), PTE(40, 1), SPE( 6, 40, 1), DUES,
4. 1UE(40), RHOE(40), VMUE(40), TE(40), UEDGE, DUEGE, D2UEDG, VMWE, HE, C90
5. 2, DSIP(40), IDSIP, TTV, TVCC(40)
6. COMMON/INTCOM/ KR(20), KIN, KOUT, MAT1I, MAT2I, MAT1J, MAT2J, NETA, I, IS, N
7. 1, IT, NTIME, NSP, NSPM1, NAM, NLEQ, NNLEQ, NRNL, ITS, KAPPA, CBAR, CASE(15)
8. 2, B(8), MWE, NON, KQ(10), ITEM, NITEM, KRI7, NBT, NBT2, IDENT, KRQ(40)
9. 3, KAUXO, JTIME, JSPEC, MD(3)
10. COMMON/PRMCOM/TIME( 50), PRE(40), PTET( 50), GE( 50), S(40), ROKAP(40)
11. 1, RNOSE, VKAP, NDISC, IDISC(40), NSD(5), MSD(5), ITF( 50), IPRE, RADNO, CONE
12. 2, RADFL( 50), RADR(40), RADSS(40), IRAD
13. COMMON/PRPCOM/PR(15), T(15), RHO(15), SC(15), CAPC(15), GR(15), H(15)
14. 1, CPBAR(15), VMW(15), PHIK(15, 6), DRHOH, DRHOK( 6), ZK( 6), DZKH( 6), D
15. 2MU3K( 6), DMU4K( 6), DTK( 6), DPHIKH( 6), DPRK( 6), DSCK( 6), DCAPCK( 6)
16. 3, DHTILK( 6), DQRK( 6), DCPBK( 6), DCPTK( 6), DMU12K( 6), DZKK( 6, 6)
17. 4, DPHIKK( 6, 6), DMU4H, DMU3H, DHTILH, VMU12, CT, CTR, CPTIL, HTIL
18. 5, VMU3, DTH, DCAPCH, DPRH, DSCH, DQRH, DCPBH, DCPTH, DMU12H, VMU(15), RHOP
19. 6(15), PHIKP(15), HP, TP, ZKP( 6), VMU3P, VMU4P, HTILP, CRHO(14), GMR(15)
20. COMMON/STTCOM/GAM1, PRDUM, PRA, PRB, PRC, PRD, VMUA, VMUB, VMUC, VMUD, NC,
21. 1 FLD(7, 3), VMWD, TR(3), L
22. COMMON/UNICOM/UCD, UCE, UCL, UCM, UCP, UCR, UCS, UCT, UCV, ITDK, IUNIT
23. DIMENSION DUM(10)
24. VMWE=VMWD
25. KQ(6)=KQ(6)-1
26. KQ(7)=1ABS(KR(18)*5)-4
27. IF (KQ(5)-1) 300, 200, 100
28. C STAGNATION SOLUTION
29. 100 WRITE(KOUT, 991)
30. TE(15)=TR(1)+500.
31. IHET=50
32. L=2
33. HE=GE(ITEM)
34. 110 HET=HHOMO(TE(15))
35. CPT=CHOMO(TE(15))
36. ERC=(HET-HE )/CPT
37. ITER=51-IHET
38. ERC=SIGN(AMINI(ABS(ERC), 700.), ERC)
39. TE(15)=TE(15)-ERC
40. IF (TE(15) .LE. 0.0) TE(15) =50.
41. L=2
42. IF(TE(15).LT.TR(1)) L=1
43. IF(TE(15).GE.TR(2)) L=3
44. IHET=IHET-1
45. IF (IHET) 400, 400, 140
46. 140 IF (ABS(ERC)-.1) 150, 150, 110
47. 150 SSTAG=SHOMO(TE(15))
48. IF(KQ(5).NE.1) GO TO 156
49. VMACH=SQRT(2.*(GE(ITEM)-HE)*VMWE/GAM1/TE(15)/1.9869)
50. SSTAGA=SSTAG-1.9869/VMWE*ALOG(PE(15, 1))
51. GO TO 160
52. 156 CONTINUE
53. DO 155 II=1, NS
54. 155 TE(II)=TE(15)
55. VMACH=0.
56. 160 RHOE(15)=PE(15, IT)/TE(15)*VMWE/0.7303
57. UE(15)=SQRT((GE(ITEM)-HE )*50073.)
58. VMUE(15)=(VMUA*TE(15)+VMUB)/(VMUC*TE(15)+VMUD)
59. GAM1=CPT/(CPT-1.9869/VMWE)
60. IF (KQ(5).EQ.2) GO TO 165
61. C PREPARE EDGE OUTPUT IN PROPER UNITS

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62.      DUM(1)=S(IS)/UCL
63.      DUM(2)=TE(IS)/UCT
64.      DUM(3)=CPT/UCF*UCT
65.      DUM(4)=PE(IS,IT)/UCP
66.      DUM(5)=RHDE(IS)/UCD
67.      DUM(6)=VMUE(IS)/UCV
68.      DUM(7)=UE(IS)/UCL
69.      DUM(8)=HE/UCF
70.      DUM(9)=SSTAGA*UCT/UCF
71.      DUM(10)=VMACH
72.      WRITE(KOUT,995) IS,(DUM(I),I=1,10)
73.      GO TO 166
74.      C    PREPARE STAGNATION OUTPUT IN PROPER UNITS
75.      165 DUM(1)=TE(IS)/UCT
76.      DUM(2)=PTET(ITEM)/UCP
77.      DUM(3)=GAM1
78.      DUM(4)=HET/UCF
79.      DUM(5)=(SSTAG-1.9869/VMWE*ALOG(PTET(ITEM)))/UCF*UCT
80.      DUM(6)=CPT/UCF*UCT
81.      DUM(7)=RHDE(IS)/UCD/PRE(IS)
82.      DUM(8)=VMUE(IS)/UCV
83.      IF(IUNIT.EQ.0)WRITE(KOUT,1993)(DUM(I),I=1,8)
84.      IF(IUNIT.EQ.1)WRITE(KOUT,993)(DUM(I),I=1,8)
85.      166 KQ(6)=-1
86.      170 RETURN
87.      C    EDGE CALCULATIONS
88.      200 SSTAG=SSTAG-DSIP(IS)
89.      SSTAGA=SSTAG+1.9869/VMWE*ALOG(1./PTET(ITEM))
90.      DUM1=SSTAG+1.9869/VMWE*ALOG(PRE(IS))
91.      IST=50
92.      IF(ITF(15).EQ.0)GO TO 210
93.      C    EDGE CALCULATIONS FOR UEI INPUT
94.      IHET=50
95.      GO TO 110
96.      210 DS=-DUM1+SHOMO(TE(IS))
97.      CPT=CHOMO(TE(IS))
98.      ERC=DS*TE(IS)/CPT
99.      ITER=51-IST
100.     ERC=SIGN(AMIN1(ABS(ERC),700.),ERC)
101.     TE(IS)=TE(IS)-ERC
102.     IF (TE(IS) .LE. 0.0) TE(IS) =50.
103.     L=2
104.     IF(TE(IS).LT.TR(1))L=1
105.     IF(TE(IS).GE.TR(2))L=3
106.     IST=IST-1
107.     IF (IST) 400,400,220
108.     220 IF (ABS(ERC)=-.1)230,230,210
109.     230 HE=HHOMO(TE(IS))
110.     VMACH=SQRT(2.*(GE(ITEM)-HE)*VMWE/GAM1/TE(IS)/1.9869)
111.     GO TO 160
112.     C    BOUNDARY LAYER CALCULATIONS
113.     300 IHT=50
114.     IF (IS+ITEM-2)301,301,302
115.     301 T(I)=TR(1)+500.
116.     302 L=2
117.     IF(T(I).LT.TR(1))L=1
118.     IF(T(I).GE.TR(2))L=3
119.     HT=HHOMO(T(I))
120.     CPBAR(I)=CHOMO(T(I))
121.     ERC=(HT-H(I))/CPBAR(I)
122.     ERC=SIGN(AMIN1(ABS(ERC),700.),ERC)
123.     T(I)=T(I)-ERC
124.     IF (T(I) .LE.0.0) T(I) = 50.
125.     IHT=IHT-1

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B14A, STATE

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126.      IF(IHT)400,400,310
127.      310 IF(ABS(ERC)-.1)320,320,302
128.      320 CPTIL=CPBAR(I)
129.      DTH=1./CPBAR(I)
130.      DCPBH=0.0
131.      DCPTH=DCPBH
132.      PR(I)=PRDUM+PRA*T(I)**PRB+PRC*T(I)**PRD
133.      DPRH=DTH*(PRA*PRB*T(I)**(PRB-1.)+PRC*PRD*T(I)**(PRD-1.))
134.      SC(I)=PR(I)
135.      DSCH=DPRH
136.      RHO(I)=RHOE(1S)/T(I)*TE(1S)
137.      DRHOH=-RHO(I)/T(I)*DTH
138.      VMU(I)=(VMUA*T(I)**VMUB)/(VMUC*T(I)+VMUD)
139.      VMW(I)=VMWE
140.      CAPC(I)=(T(I)/TE(1S))**((VMUB-1.)/(VMUC*T(I)+VMUD))+
141.      1(VMUC*TE(1S)+VMUD)
142.      DCAPCH=CAPC(I)*DTH+((VMUB-1.)/T(I)-VMUC/(VMUC*T(I)+VMUD))
143.      HTIL=H(I)
144.      GMR(I)=CPBAR(I)/(CPBAR(I)-1.9869/VMWE)
145.      DHTILH=1.
146.      VMU12=VMWE
147.      DMU12H=0.
148.      VMU3=1./VMWE
149.      DMU3H=0.
150.      DMU4H=0.
151.      QR(I)=0.
152.      DQRH=0.
153.      CT=0.
154.      CTR=0.
155.      RETURN
156.      400 WRITE(KOUT,99)KQ(5)
157.      99 FORMAT(//40H***** STATE DOES NOT CONVERGE FOR KQ(5)=12.6H *****//)
158.      991 FORMAT(1H1,10X19HSTAGNATION SOLUTION /12X15HEDGE CONDITIONS //)
159.      1993 FORMAT(5X14HTEMPERATURE = E11.4, 6H DEG K //5X14HPRESSURE = E11
160.      1.4, 5H N/M2 //5X14HGAMMA = E11.4, //5X14HENTHALPY = E11.4,
161.      210H J/KG //5X14HENTROPY = E11.4, 16H J/KG-DEG K //
162.      35X14HCP-FROZEN = E11.4, 16H J/KG-DEG K //, 5X14HDENSITY =
163.      4 E11.4, 6H KG/M3, //5X14HVISCOSITY = E11.4, 7H N-S/M2 )
164.      993 FORMAT(5X14HTEMPERATURE = E11.4, 6H DEG R //5X14HPRESSURE = E11
165.      1.4, 12H ATMOSPHERES //5X14HGAMMA = E11.4, //5X14HENTHALPY =
166.      2 E11.4, 8H BTU/LBM, //5X14HENTROPY = E11.4, 14H BTU/LBM-DEG R, //
167.      35X14HCP-FROZEN = E11.4, 14H BTU/LBM-DEG R, //5X14HDENSITY =
168.      4E11.4, 8H LBM/FT3, //5X14HVISCOSITY = E11.4, 9H LBM/S-FT )
169.      995 FORMAT(I3,10(2X,1PE10.3))
170.      STOP
171.      END

```

B14B, STATEN

```

1. C8148 SUBROUTINE STATEN
2. COMMON/INTCOM/KR(20),KIN,KOUT
3. COMMON/EQTCOM/TK(20,2),VMW(20),EF(7,3,20),TJ(3),PVOL(20),ISN(3,20)
4. 1,PVMW(20)
5. COMMON/STTCOM/GAM1,PRDUM,PRA,PRB,PRC,PRD,VMUA,VMUB,VMUC,VMUD,NC,
6. 1 FLD(7,3),VMWD,TR(3),L
7.
8. 8000 READ (KIN,3) PRDUM,PRA,PRB,PRC,PRD
9. READ (KIN,3) VMUA,VMUB,VMUC,VMUD
10. READ(KIN,2)NC,IFRAC,ITEMP,KU,(TJ(I),I=1,3)
11. READ(KIN,3)(TK(I,1),VMW(I),I=1,NC)
12. C TK AND VMW MUST BE IN SAME ORDER AS THE SPECIES PROPERTY CARDS
13. IF(ITEMP.EQ.0)GO TO 102
14. K2=3
15. K1=2
16. KZ=1
17. GO TO 103
18. 102 K2=2
19. K1=1
20. 103 DO 101 JJ=1,NC
21. READ(KIN,4)(ISN(I,JJ),I=1,3)
22. READ(KIN,8)(EF(I,K2,JJ),I=1,5)
23. READ(KIN,8) EF(6,K2,JJ),EF(7,K2,JJ),(EF(I,K1,JJ),I=1,3)
24. READ(KIN,8)(EF(I,K1,JJ),I=4,7),EDUM
25. IF(ITEMP.EQ.0)GO TO 101
26. READ(KIN,8)(EF(I,KZ,JJ),I=1,5)
27. READ(KIN,8) EF(6,KZ,JJ),EF(7,KZ,JJ)
28. 101 CONTINUE
29. VVOL=0.0
30. C CALCULATE MOLE FRACTION ,TK(I,2)
31. IF (IFRAC.EQ.1) GO TO 8111
32. DO 802 I=1,NC
33. PVOL(I)=TK(I,1)/VMW(I)
34. A02 VVOL=VVOL+PVOL(I)
35. DO 803 I=1,NC
36. A03 TK(I,2)=PVOL(I)/VVOL
37. GO TO 8112
38. 8111 DO 804 I=1,NC
39. A04 VVOL=VVOL+TK(I,1)
40. DO 801 I=1,NC
41. A01 TK(I,2)=TK(I,1)/VVOL
42. C CALCULATE MIXTURE MOLECULAR WT.
43. 8112 DO 805 I=1,NC
44. A05 PVMW(I)=TK(I,2)*VMW(I)
45. VMWE=0.
46. DO 806 I=1,NC
47. A06 VMWE=VMWE+PVMW(I)
48. VMWD=VMWE
49. C CALCULATE MASS FRACTION, TK(I,1)
50. DO 807 I=1,NC
51. A07 TK(I,1)=PVMW(I)/VMWE
52. A08 DO 8106 JI=1,7
53. DO 8106 JJ=1,3
54. 8106 FLD(JI,JJ)=0.
55. C CALCULATION OF MIXTURE PROPERTIES
56. DO 8107 JK=1,3
57. DO 8107 JJ=1,NC
58. DO 8107 JI=1,7
59. 8107 FLD(JI,JK)=FLD(JI,JK)+EF(JI,JK,JJ)*TK(JJ,2)
60. C OUTPUT PROPERTIES DATA
61. WRITE(KOUT,7)VMUA,VMUB,VMUC,VMUD,PRDUM,PRA,PRB,PRC,PRD

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B14B, STATEN

```

62.      IF(KU.EQ.0)GO TO 201
63.      WRITE(KOUT,71)
64.      GO TO 202
65. 201 WRITE(KOUT,72)
66. 202 WRITE(KOUT,9)
67.      WRITE(KOUT,10)(TJ(I),(FLD(J,I),J=1,7),I=1,K2)
68.      WRITE(KOUT,78)
69.      DO 212 JJ=1,NC
70. 212 WRITE(KOUT,79)(ISN(I,JJ),I=1,3),TK(JJ,2),TK(JJ,1)
71.      WRITE(KOUT,80)VMWE
72.  C    CALCULATE PROPERTIES RELATIONS FOR T IN DEG. R
73.      C=1./1.8
74.      C2=C*C
75.      RM=1.9869/VMWE
76.      CV=.671968995
77.      DO 203 I=1,K2
78.      FLD(1,I)=FLD(1,I)*RM
79.      FLD(2,I)=FLD(2,I)*RM*C
80.      FLD(3,I)=FLD(3,I)*RM*C2
81.      FLD(4,I)=FLD(4,I)*RM*C2*C
82.      FLD(5,I)=FLD(5,I)*RM*C2*C2
83.      FLD(6,I)=FLD(6,I)*RM/C
84. 203 FLD(7,I)=FLD(7,I)*RM +FLD(1,I)*ALOG(C)
85.      IF(KU.EQ.1) GO TO 204
86.      PRA=PRA*C**PRB
87.      PRC=PRC*C**PRD
88.      VMUA=CV*VMUA*C**VMUB
89.      VMUC=VMUC*C
90. 204 CONTINUE
91.      TR(1)=TJ(2)*1.8
92.      TR(2)=TJ(3)*1.8
93.      IF(ITEMP.EQ.0) GO TO 206
94.      DO 205 I=1,3
95. 205 TR(I)=TJ(I)*1.8
96. 206 CONTINUE
97.      2 FORMAT(I3,2X,3I1,2X,3F10.3)
98.      3 FORMAT (6E10.3)
99.      4 FORMAT(3A4)
100.     7 FORMAT(/9X20HVISCOSITY LAW MU=(E10.3,4H*T**E10.3,3H)/(E10.3,3H*T
101.     1+E10.3,1H)//9X19HPRANDTL NUMBER PR=E10.3,1H+E10.3,4H*T**E10.3,1H+
102.     2E10.3,4H*T**E10.3,/)
103.     71 FORMAT (9X,15HTEMP, IN DEG. R,5X, 21HVISCOSITY IN LHM/S-FT)
104.     72 FORMAT (9X,15HTEMP, IN DEG. K,5X, 21HVISCOSITY IN N-S/M2 )
105.     8 FORMAT(5E15.8)
106.     9 FORMAT(/49X35HMIXTURE CURVE FIT CONSTANTS (DEG K)/)
107.     10 FORMAT(F10.2,7E17.8)
108.     79 FORMAT(1H0,5X,3A4,8X,2(2XE10.4))
109.     78 FORMAT(1H1/////21X13HFLUID MIXTURE ///11X9HCOMPONENT 10X4HMOLE
110.     18X4HMASS /28X8HFRACTION 4X8HFRACTION /)
111.     80 FORMAT(/5X18HMOLECULAR WEIGHT = F12.7//)
112.     RETURN
113.     END

```

B14C, HHOMO

```

1. CB14C
2. FUNCTION HHOMO(T)
3. COMMON/STTCOM/DUM(11),A(7,3),DUM2(4),L
4. C THE A'S ARE THE FLD OF B14B
5. HHOMO =A(6,L)+T*(A(1,L)+T*(A(2,L)/2.+T*(A(3,L)/3.+T*(A(4,L)+T*
6. 1A(5,L)/4.))))
7. RETURN
8. END

```

B14D, CHOMO

```

1. CB14D
2. FUNCTION CHOMO(T)
3. COMMON/STTCOM/DUM(11),A(7,3),DUM2(4),L
4. C THE A'S ARE THE FLD OF B14B
5. CHOMO =A(1,L)+T*(A(2,L)+T*(A(3,L)+T*(A(4,L)+T*A(5,L))))
6. RETURN
7. END

```

B14E, SHOMO

```

1. CB14E
2. FUNCTION SHOMO(T)
3. COMMON/STTCOM/DUM(11),A(7,3),DUM2(4),L
4. C THE A'S ARE THE FLD OF B14B
5. SHOMO =A(7,L)+A(1,L)*ALOG(T)+T*(A(2,L)+T*(A(3,L)/2.+T*(A(4,L)/3.
6. 1+T*A(5,L)/4.)))
7. RETURN
8. END

```

B15B, RERAY

```

1. SUBROUTINE RERAY(N,C,NQ,D,NGN,LS,IS,ND,SD,L,S,LL,LLL)
2. C DIRECT INVERSION PROCEDURE -- C IS REPLACED BY C*+1
3. DIMENSION D(ND,1),SD(1),C(ND,1),L(1),S(1),LL(1),LLL(1),LS(1)
4. NNN=IABS(NGN)
5. NN = IABS(NQ)
6. KOUT=6
7. N1 = N + 1
8. NP = N + NN
9. DO 15 I=1,NP
10. LLL(I) = I
11. IF (LS(1)) 10,10,5
12. 5 L(I) = LS(I)
13. GOTO 15
14. 10 L(I) = I
15. CONTINUE
16. IX = - 1
17. IF (IS + 2) 45,35,45
18. 20 FORMAT(11H L(I),I=1,13,5X (30I3))
19. 25 FORMAT(15H ((C(I,J),J=1,13,12H),(D(J),J=1,13, 6H),I=1,13,15H) 8E
20. 1FORE RERAY)
21. 30 FORMAT(2X 11E10,3/(12X 10E10,3))
22. 35 WRITE(KOUT,25)NP,NNN,N
23. WRITE(KOUT,20)NP,(L(I),I=1,NP)
24. IX = 0
25. DO 40 I=1,N
26. 40 WRITE(KOUT,30)(C(I,J),J=1,NP),(D(I,J),J=1,NNN)
27. 45 IS = - 1
28. C TRIANGULATE MATRIX
29. DO 130 I=1,N
30. DO 50 M=1,NP
31. 50 S(M)=ABS(C(I,M))
32. IF (IS) 55,60,60
33. 55 IS = 0
34. GOTO 90
35. C REDUCE ROW I BY PRECEEDING ROWS
36. DO 85 J=2,I
37. K = L(J - 1)
38. DIV = - C(I,K)
39. IF (DIV) 65,85,65
40. 65 C(I,K) = 0.
41. DO 70 M=1,NP
42. DIVC = DIV * C(J - 1,M)
43. S(M)=AMAX1(S(M),ABS(DIVC))
44. 70 C(I,M) = C(I,M) + DIVC
45. IF (NNN) 85,85,75
46. 75 DO 80 M=1,NNN
47. 80 D(I,M) = D(I,M) + DIV * D(J - 1,M)
48. 85 CONTINUE
49. C SEEK MAXIMUM PIVOT
50. 90 DIV = 0.
51. DO 100 JJ=I,N
52. M = L(JJ)
53. IF (ABS(C(I,M)) - DIV) 100,100,95
54. 95 DIV = ABS(C(I,M))
55. K = M
56. J = JJ
57. IF (I.LE.3) GO TO 100
58. IF(ND=20) 100,100,101
59. 100 CONTINUE
60. 101 SD(I)=DIV/S(K) ,
61. L(J)=L(I)

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```

62.      L(I)=K
63.      IF(SD(I)=1.E-8) 104,104,110
64.      104 C(I,K)=0,
65.      IF(SD(I)) 105,105,90
66.      C      SINGULAR MATRIX RETURN
67.      105 IS=-1
68.      WRITE(KOUT,135) (II,L(II),SD(II),II=1,I)
69.      RETURN
70.      110 DIV = C(I,K)
71.      C(I,K) = 1.0
72.      K = LLL(J)
73.      LLL(J) = LLL(I)
74.      LLL(I) = K
75.      LL(K) = I
76.      C      NORMALIZE ROW
77.      IF (NNN) 125,125,115
78.      115 DO 120 J=1,NNN
79.      120 D(I,J) = D(I,J) / DIV
80.      125 DO 130 J=1,NP
81.      130 C(I,J) = C(I,J) / DIV
82.      IF (IX) 145,140,145
83.      135 FORMAT(24H PIVOT ROW/COL/RES.RATIO 5(I4,1H/I3,1H/E9.2,1H,))
84.      140 WRITE(KOUT,135)(I,L(I),SD(I),I=1,NP)
85.      C      DIAGONALIZE MATRIX
86.      145 NM = N - 1
87.      C      INTERCHANGE COLUMNS
88.      DO 225 II=1,NP
89.      I = II
90.      180 J = L(I)
91.      L(I) = I
92.      IF (J = I) 185,225,185
93.      185 IF (IS) 200,190,200
94.      190 DO 195 M=1,N
95.      S(M) = C(M,I)
96.      195 C(M,I) = C(M,J)
97.      IS = I
98.      I = J
99.      GOTO 180
100.      200 IF (IS = J) 205,215,205
101.      205 DO 210 M=1,N
102.      210 C(M,I) = C(M,J)
103.      I = J
104.      GOTO 180
105.      215 DO 220 M=1,N
106.      220 C(M,I) = S(M)
107.      IS = 0
108.      225 CONTINUE
109.      IF(NQN + NQ) 149,149,144
110.      144 IF(NQN+NQ=NN=NNN) 149,147,149
111.      C*****SOLUTION VECTOR ONLY
112.      147 K=N
113.      DO 153 I=1,NM
114.      K=K-1
115.      DO 153 IL=K,NM
116.      DUM=C(K,IL+1)
117.      IF (NN) 152,152,151
118.      151 DO 146 M=1,NP
119.      146 C(K,M) = C(K,M) - DUM * C(IL+1,M)
120.      C(K,1)=C(K,1)-DUM*C(IL+1,1)
121.      IF (NNN) 153,153,152
122.      152 DO 148 M=1,NNN
123.      148 D(K,M)=D(K,M)-DUM*D(IL+1,M)
124.      153 CONTINUE
125.      GO TO 176

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B15B, RERAY

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126. C****FULL INVERSION AND SOLUTION VECTOR
127.   DO 175 I=1,NM
128.     DO 175 J=1,I
129.       DIV = - C(J,I+1)
130.       IF (DIV) 150,175,150
131.       150 C(J,I+1) = 0.
132.       IF (NNN) 165,165,155
133.       155 DO 160 M=1,NNN
134.         160 D(J,M) = D(J,M) + DIV * D(I + 1,M)
135.       165 DO 170 M=1,NP
136.         170 C(J,M) = C(J,M) + DIV * C(I + 1,M)
137.       175 CONTINUE
138. C   INTERCHANGE ROWS
139.   176 DO 320 II=1,N
140.     I = II
141.     230 J = LL(I)
142.     LL(I) = I
143.     IF (J = I) 235,320,235
144.     235 IF (IS) 265,240,265
145.     240 DO 245 M=1,NP
146.       S(M) = C(I,M)
147.       245 C(I,M) = C(J,M)
148.       IF (NNN) 260,260,250
149.       250 DO 255 M=1,NNN
150.         SD(M) = D(I,M)
151.         255 D(I,M) = D(J,M)
152.       260 IS = I
153.       I = J
154.       GOTO 230
155.     265 IF (IS = J) 270,295,270
156.     270 DO 275 M=1,NP
157.       275 C(I,M) = C(J,M)
158.       IF (NNN) 290,290,280
159.       280 DO 285 M=1,NNN
160.         285 D(I,M) = D(J,M)
161.       290 I = J
162.       GOTO 230
163.     295 DO 300 M=1,NP
164.       300 C(I,M) = S(M)
165.       IF (NNN) 315,315,305
166.       305 DO 310 M=1,NNN
167.         310 D(I,M) = SD(M)
168.       315 IS = 0
169.       320 CONTINUE
170.       IF (IX) 340,330,340
171.       325 FORMAT(15H ((C(I,J),J=1,I3,12H),(D(J),J=1,I3, 6H),I=1,I3,15H) AF
172.       1TER RERAY )
173.       330 WRITE(KOUT,325)NP,NNN,N
174.       DO 335 I=1,N
175.       335 WRITE(KOUT,30)(C(I,J),J=1,NP),(D(I,J),J=1,NNN)
176.       340 RETURN
177.     END

```

B16A, SLOPQ

```

1.  CB16A
2.  SUBROUTINE SLOPQ(N,X,Y,S,Z)
3.  DIMENSION X(1),Y(1),S(1),Z(1)
4.  S(1)=0.
5.  IF(N=1) 9,9,8
6.  8 S(2)=(Y(2)-Y(1))/(X(2)-X(1))
7.  S(1)=S(2)
8.  QC=S(2)
9.  DO 7 I=1,N
10. IF(I+1=N)2,1,6
11. 1 QB=QC
12. IF (I-2)7,6,5
13. 2 XOT=X(I)-X(I+1)
14. XTT=X(I+1)-X(I+2)
15. XTO=X(I+2)-X(I)
16. AA=Y(I)/(XOT+XTO)
17. XOTT=XOT*XTT
18. AB=Y(I+1)/XOTT
19. AC=Y(I+2)/(XTT+XTO)
20. AAA=AA*XTT
21. ABB=AB*XTO
22. ACC=AC*XOT
23. QA=QC
24. QB=S(I)
25. QC=S(I+1)
26. S(I)=AA*(XTO-XOT)+ABB-ACC
27. S(I+1)=AB*(XOT-XTT)+ACC-AAA
28. S(I+2)=AC*(XTT-XTO)+AAA-ABB
29. 3 IF(I-2)7,5,4
30. 4 S(I)=(S(I)+QA)/2.
31. 5 S(I)=(S(I)+QB)/2.
32. 6 XD=X(I)-X(I-1)
33. YS=Y(I)+Y(I-1)
34. SD=S(I)-S(I-1)
35. SS=S(I)
36. Z(I)=Z(I-1)+XD/2.*(YS-XD/6.+SD)
37. S(I)=SS
38. 7 CONTINUE
39. 9 RETURN
40. END

```

B16B, SLOPL

```

1.      SUBROUTINE SLOPL(N,X,Y,S,Z)
2.      DIMENSIONX(N),Y(N),S(N),Z(N)
3.      NM = N-1
4.      S(1) = (Y(2) -Y(1) )/(X(2)-X(1))
5.      S1 = S(1)
6.      IF(NM.NE.1) GO TO 1
7.      S(2)=S(1)
8.      GO TO 2
9.      1 CONTINUE
10.     DO 5 I = 2,NM
11.         S2 = (Y(I+1)-Y(I))/(X(I+1)-X(I))
12.         S(I) = (S1+S2)/2.
13.     5   S1 = S2
14.     S(N) = S2
15.     2 DO 10 I=2,N
16.         10 Z(I) = Z(I-1)+(Y(I)+Y(I-1))/2.0*(X(I)-X(I-1))
17.     RETURN
18.     END

```

B17A, ABMAX

```

1.      CB17A
2.      SUBROUTINE ABMAX(N,X,XM,I)
3.      DIMENSION X(1)
4.      I=1
5.      XM=ABS (X(1))
6.      IF (N-1) 4,4,5
7.      5 DO 3 J=2,N
8.          XT=ABS (X(J))
9.          IF(XM-XT) 2,3,3
10.     2 XM=XT
11.     I=J
12.     3 CONTINUE
13.     4 XM=X(I)
14.     RETURN
15.     END

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1.  CB18A
2.  SUBROUTINE MATS1(X)
3.  COMMON/INTCOM/KR(20),KIN,KOUT,MAT1I,MAT2I,MAT1J,MAT2J,NETA
4.  COMMON/ETACOM/ETA(15),DETA(15)
5.  DIMENSION X(1),A(14),B(14),C(14)
6.  IF(KR(1).LT.-50) GO TO 17
7.  JB=NETA
8.  IF(KR(10)-1) 11,18,19
9.
10. 17 JB=2
11.  X(NETA)=X(NETA)+X(1)
12.  IF(KR(10)-1) 11,18,19
13. 18 LIM=NETA-2
14.  GO TO 20
15. 19 LIM=NETA-1
16. 20 J=JB
17.  K=JB+NETA-1
18.  XJ=0.
19.  DO 25 I=1,LIM
20.  XK=(X(J)/DETA(I)-XJ)*2.
21.  X(J)=-X(K)+XK
22.  X(K)=XK/DETA(I)
23.  IF(JB=2) 21,23,21
24. 23 IF(I+1=NETA) 24,27,27
25. 21 X(I)=(XJ/2.+XK/6.)*DETA(I)*DETA(I)-X(I)
26.  IF(I+1=NETA) 22,27,27
27. 22 X(I+1)=X(I+1)-X(I)
28. 24 XJ=X(J)
29.  X(K+1)=X(K+1)-XJ
30.  J=J+1
31. 25 K=K+1
32.  I=NETA-1
33.  X(K)=X(K)+X(K+1)
34.  XK=(3.+(X(J)/DETA(I)-XJ)-X(K))*2.
35.  XKP=X(K)*2.-XK
36.  X(J)=X(K+1)
37.  X(K+1)=XKP/DETA(I)
38.  X(K)=XK/DETA(I)
39.  IF(JB=2) 26,27,26
40. 26 X(I)=(XJ/2.+XK/8.+XKP/24.)*DETA(I)*DETA(I)-X(I)
41. 27 RETURN
42. 11 DSV=DETA(NETA)
43.  DETA(NETA)=0.
44. 1 B(1)=.5
45.  A(1)=DETA(1)/4.+DETA(2)/2.
46.  DO 2 I=3,NETA
47.  C(I-2)=DETA(I-1)/(6.+A(I-2))
48.  B(I-1)=.5-C(I-2)*B(I-2)
49. 2 A(I-1)=(1./3.-C(I-2)*B(I-2))*DETA(I-1)+B(I-1)*DETA(I)
50. 12 J=NETA-1
51.  K=J+JB-1
52.  L=K+J
53.  X(L)=X(L)+X(L+1)
54. 3 X(L-1)=X(L-1)+X(L)
55.  X(L)=X(L)-X(K)/DETA(J)
56.  L=L-1
57.  K=K-1
58.  J=J-1
59.  IF (J=1) 4,4,3
60. 4 X(L)=X(L)-X(K)/DETA(1)*1.5
61.  J=L
62.  DO 5 I=3,NETA

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B18A, MATS1

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62.      X(J+1)=X(J+1)-C(I-2)*X(J)
63.      5 J=J+1
64.      X9=X(J+1)
65.      I=NETA-1
66.      GO TO 8
67.      6 M=L
68.      DUM=X(J+1)*(DETA(I+1)+DETA(I+2))
69.      DO 7 K=1,I
70.      X(M)=X(M)-DUM*B(K)
71.      7 M=M+1
72.      J=J-1
73.      8 X(J+1)=X(J)/A(I)
74.      I=I-1
75.      IF (I) 9,9,6
76.      9 DUM=DETA(1)*DETA(1)
77.      X(J)=X(JB)/DUM*3.-.5*X(J+1)
78.      IF(JB-2) 13,14,13
79.      13 X(1)=DUM*DETA(1)+(X(J)/8.+X(J+1)/24.)-X(1)
80.      14 L=JB
81.      DO 10 I=3,NETA
82.      J=J+1
83.      X(L)=X(L+1)/DETA(I-1)-DETA(I-1)/3.+(X(J)+.5*X(J+1))
84.      IF(JB-2) 15,10,15
85.      15 DUM=DETA(I-1)+DETA(I-1)
86.      X(I-1)=X(I-2)-X(I-1)+DUM*(X(L)/2.+DETA(I-1)*(X(J)/8.+X(J+1)/24.))
87.      10 L=L+1
88.      X(L)=X9
89.      DETA(NETA)=DSV
90.      RETURN
91.      END

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B18B, MATS2

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1.      SUBROUTINE MATS2(X)
2.      DIMENSION X(1)
3.      COMMON/INTCOM/KR(20)
4.      KR(1)=KR(1)-100
5.      CALL MATS1(X)
6.      KR(1)=KR(1)+100
7.      RETURN
8.      END

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CB19A

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1. SUBROUTINE TRMBL(ILK)
2. DIMENSION EPSOUT( 75)
3. COMMON/CEBCOM/C10W,C56W,TAUW,DRHOW(7),DCAPCW(7),OYA(123),CAPY,UTAU
4. 1,VWP,PPL,ACEB,ACY,CCEB,ABECK,CBECK,BBECK,DELTA(40),IPRT
5. DIMENSION XP(4)
6. COMMON/COECOM/
7. C5,C6,C7,C8,C9,C10,C11,C12,C13,C14,C15
8. 1,C16,C17,C18,C19,C20,C21,C22,C23,C24,C25,C26,C27,C28,C29,C30,C31,C
9. 232,C33,C34,C35,C36,C37,C38,C39,C40,C41,C42,C43,C44,C45,C46,C47,C48
10. 3,C49,C50,C51,C52,C53,C54,C55,C56,C57,C58,C59,C60,C61,C62,C63,C64,C
11. 465,C66,C67,C68,C69,C70,C71,C72,C73,C74,C75,C76,C77,C78,C79,C80,C81
12. 5,C82,C83,C84,C85,C86,C87,C88
13. COMMON/COECON/ CK1( 6),CK2( 6),CK3( 6),CK4( 6),CK5( 6),CK6( 6)
14. 1,CK7( 6),CK8( 6),CK9( 6),CK10( 6),CK11( 6),CK12( 6),CK13( 6)
15. 2,CK14( 6),CK15( 6),CK16( 6),CK17( 6),CK18( 6),CK19( 6),CK20( 6)
16. 3,CK21( 6),CK22( 6),CKK1( 6, 6),CKK2( 6, 6),XM(5),XG(5),XSP(5, 7)
17. 4,CKK3( 6, 6)
18. COMMON/EDGCOM/ PE(40, 1),PTE(40, 1),SPEC( 6,40, 1),DUES,
19. 1UE(40),RHOE(40),VMUE(40),TE(40),UEDGE,DUEDGE,D2UEDG,VMWE,HE,C90
20. 2,DSIP(40),IDSIP,TTVC,TVCC(40),HEA(40),SF(20),CS(20),CSPR(20),
21. 3 CG(20),CGP(20),8REP,GEP,NEN
22. COMMON/EPSCOM/ELCON,YAP,CLNUM,SCT,PRT,RED,DVS,RHOVS,PI,PIM,CL,
23. 1 EPSA(15),EPS1,EL(15),DPI(15,2),DEPC,TREF,RETR,VINTR(15)
24. COMMON/ERRCOM/FLE( 43),GLE(30),SPLE(30, 6),ELA(253),FLEM,GLEM
25. 1,SPLEM( 6),ELM(14),ELMM,IFLM,IGLM,I8PLM( 6),NELM,ILMM,DFL(43)
26. 2,DGL(30),DSPL(30, 6),FNLE(18),GNLE(15),SPNLE(15, 6),ENL(123)
27. 3,FNLEM,GNLEM,SPNLEM( 6), ENLMM,IFNLM,IGNLM,I8PNLM( 6)
28. 4,NENLM,INLMM,DFNL(18),DGNL(15),DSPNL(15, 6),DRNL( 8)
29. COMMON/ETACOM/ETA(15),DETA(15),DSQ(14),DCU(14),R1(14),B2(14)
30. 1,LAR(123),BA1(43,18),BA2(30,15)
31. COMMON/HISCOM/C1,C2,C3,C4,ALPHD,BETA,ZM(4,14),ZG(4,14),ZSP(4,14, 6
32. 1 ),XI(40),HF(15,5),HG(15,3),HSP(15,3, 6),HALPH,HUE,HHUE,HFW,DLX2
33. 2,C3M(40),BETAM(40)
34. COMMON/INTCOM/ KR(20),KIN,KOUT,MAT1I,MAT2I,MAT1J,MAT2J,NETA,I,IS,N
35. 18,IT,NTIME,NSP,NSPM1,NAM,NLEQ,NNLEQ,NRNL, ITS,KAPPA,CBAR,CASE(15)
36. 2,B(8), MWE,NON,KQ(10),ITEM,NITEM,KR17,NRT,NBT2,IDENT,KRQ(40)
37. 3,KAUXO,JTIME,JSPEC,MD(3)
38. COMMON/NONCOM/AM(123,123),OVNL(123),TCW,
39. 1VLNKW,DLPH( 7),DLPK( 6, 7),DTHW,DTKW( 6),FLUXJB( 7)
40. COMMON/PRPCOM/PR(15),T(15),RHO(15),SC(15),CAPC(15),QR(15),H(15)
41. 1,CPBAR(15),VMW(15),PHIK(15, 6),DRHOW,DRHOK( 6),ZK( 6),DZKH( 6), D
42. 2MU3K( 6),DMU4K( 6),DTK( 6),DPHIKH( 6),DPRK( 6),DSCK( 6),DCAPCK( 6)
43. 3,DHTILK( 6),DQRK( 6),DCPBK( 6),DCPTK( 6),DMU12K( 6),DZKK( 6, 6)
44. 4,DPHIKK( 6, 6), DMU4H,DMU3H,DHTILH,VMU12,CT,CTR,CPTIL,HTIL
45. 5,VMU3,DTH,DCAPCH,DPRH,DSCH,DGRH,DCPBH,DCPTH,DMU12H,VMU(15), RHOP
46. 6(15),PHIKP(15),HP,TP,ZKP( 6),VMU3P,VMU4P,HTILP,CRHO(14),GMR(15)
47. COMMON/VARCOM/F(4,15),G(3,15),SP(3,15, 7),ALPH
48. COMMON/TURB/STURB,DELCON,DCLNUM,TURPR(15)
49. COMMON/PRMCOM/TIME(50),PRE(40),PTET(50),GE(50),S(40),ROKAP(40)
50. COMMON/RFTCOM/RFTOUM(34),KTURB
51. EQUIVALENCE(EPSOUT(1),ELCON)
52. GO TO (1001,1002,1003,1004,1005),ILK
53. 1001 CONTINUE
54. IF (KTURB.EQ.-1) RETURN
55. 1 FORMAT(8E10,3)
56. 42 FORMAT(/30H MIXING LENGTH CONSTANT *1PE11.4
57. * /30H SUBLAYER CONSTANT, YAP *1PE11.4
58. * /30H CLAUSER NUMBER *1PE11.4)
59. 43 FORMAT(/30H BECKWITH CONSTANT *1PE11.4
60. * /30H MIXING LENGTH CONSTANT *1PE11.4
61. * /30H TURBULENT PRANDTL NUMBER *1PE11.4)

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62.      44 FORMAT(/30H      TURBULENT SCHMIDT NUMBER =1PE11.4)
63.      *      /30H      TRANSITION MOM.THICK.RE =1PE11.4)
64.      45 FORMAT(/30H      TURBULENT PRANDTL NUMBER =1PE11.4)
65.      46 FORMAT(/30H      VARIABLE TURB. PR IN USE ,
66.      *      /30H      TURBULENT PR CONSTANT =1PE11.4)
67.      47 FORMAT(/30H      CEBECI=SMITH TURB. MODEL )
68.      48 FORMAT(/30H      BECKWITH=BUSHNELL MODEL )
69.      49 FORMAT(/30H      KENDALL TURB. MODEL )
70.      IF(CLNUM.GT.0.) GO TO 2001
71.      READ(KIN,1) ELCON,YAP,CLNUM,SCT,PRT,RETR
72. 2001 CONTINUE
73.      IPRT=0
74.      IF(YAP)2002,2003,2004
75. 2002 CCEB=26.
76.      YAP= -YAP
77.      WRITE(KOUT,47)
78.      WRITE(KOUT,42)ELCON,YAP,CLNUM
79.      IF(PRT.GT.0.) WRITE(KOUT,45)PRT
80.      TPCON=-PRT
81.      IF(PRT.LT.0.) WRITE(KOUT,46) TPCON
82.      IF(PRT.LT.0.) IPRT=1
83.      WRITE(KOUT,44)SCT,RETR
84.      CTPR=34.
85.      DCCEB=CCEB
86.      DCTPR=CTPR
87.      GO TO 2003
88. 2003 CBECK=26.
89.      DB=ELCON/CLNUM
90.      BBECK=CLNUM
91.      WRITE(KOUT,48)
92.      WRITE(KOUT,43)BBECK,ELCON,PRT
93.      WRITE(KOUT,44)SCT,RETR
94.      GO TO 2005
95. 2004 WRITE(KOUT,49)
96.      WRITE(KOUT,42)ELCON,YAP,CLNUM
97.      WRITE(KOUT,45)PRT
98.      WRITE(KOUT,44)SCT,RETR
99. 2005 CONTINUE
100.      DELCON = ELCON
101.      DCLNUM = CLNUM
102.      DTPCON=TPCON
103.      KQ(10)=1
104.      KR(7)=KR(7)+2
105.      IF(RETR.GT.0.) KQ(10)=-1
106.      IF(RETR.LT.-1.999) KQ(10)=-10.01+RETR
107.      RETURN
108. 1002 CONTINUE
109. C*** CALCULATES EPS2/NUE AND ITS DERIVITIVES AS DVS AND AM(1,...)
110.      IWK=0
111. C** INTERMITTANCY CORRECTIONS
112.      DO 13 I=1,NETA
113.      IF(CBECK.GT.0.) GO TO 12
114.      IF(I.LE,KAPPA) GO TO 12
115.      VINTR(I)=1.-(ETA(I)-ETA(KAPPA))/(ETA(NETA)-ETA(KAPPA))
116.      GO TO 13
117. 12 VINTR(I)=1.0
118. 13 CONTINUE
119.      DSTURB = 2.0*STURB
120.      IF (S(19)=DSTURB) 6,7,7
121. 6 SCALE = S(19)/STURB = 1.0
122.      GO TO 8
123. 7 SCALE = 1.0
124. 8 SQRSC=SQRT(SCALE)
125.      ELCON=DELCON*SQRSC

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126.      TPCON=DTPCON*SQRSC
127.      BBECK=DCLNUM*SQRSC
128.      CLNUM = DCLNUM * SCALE
129.      NUL=0
130.      COMMENT .. C3=-DEL/VMUE , RHOVS=-DEL/VMUE*RHOV=-RED*RHOV/(RHOE*UE)
131.      RED=-C3 *RHOE(1S) *UE(1S)
132.      RC=RED*CLNUM
133.      DEL=-VMUE(1S)*C3
134.      PI=0.
135.      EPS1=0.
136.      DEPC=0.
137.      RHOVS=C1*F(1,1)+HF(1,5)
138.      IF(RC) 75,4,4
139.      4 RR=RHOE(1S)/RHO(1)
140.      RRP=RR/RHO(1)*RHOP(1)
141.      YDI=0.
142.      QI=0.
143.      QID=0.
144.      AM(1,1)=0.
145.      RK=(.995-CBAR)/(1.-CBAR)
146.      SDY=0.
147.      YDIQ=0.
148.      DVS=0.
149.      LR=117
150.      DO 66 I=1,NETA
151.      DO 3 K=1,NSP
152.      3 DRHOK(K-1)=AM(LR,K+97)
153.      RRPD=-RRP
154.      RI=RR
155.      YDS=YDI
156.      QS=QI
157.      QSD=QID
158.      RRD=RHOE(1S)/RHO(1)**2
159.      C10=C7*F(2,I)
160.      C56=F(2,I)/ALPH
161.      CRD=DRHOK*C10
162.      YDQD=-YDIQ
163.      IF(I=NETA) 5,15,15
164.      5 RR=RHOE(1S)/RHO(I+1)
165.      RRP=RR/RHO(I+1)*RHOP(I+1)
166.      RRPD=F(3,I)/RI-F(3,I+1)/RR
167.      RRPD=RRPD+RRP
168.      YDI=DETA(I)/2.*(RR+RI+DETA(I)/6.*RRPD)
169.      SDY=SDY+YDI
170.      DUM1=YDI/6.*RRFD
171.      DUM2=F(2,NETA)-(F(2,I)+F(2,I+1))*0.5
172.      DVS=DVS+YDI*(DUM2-DUM1/2.)
173.      YDIQ=YDI*YDI
174.      YDQD=YDQD+YDIQ
175.      QI=DETA(I)/2.*(DUM2-DUM1)
176.      QS=QS+QI
177.      QID=DETA(I)/2.*ALPH*DEL
178.      IF(I.EQ.KAPPA) QIDK=QID*RK
179.      YDS=YDS+YDI
180.      IF(I.EQ.KAPPA) GO TO 15
181.      QSD=QSD+QID
182.      15 DRHOI=-QS*RI/RHO(1)-F(3,I)/12.*YDQD/RHOE(1S)
183.      IF(CBECK.GT.0.) GO TO 33
184.      DUM=AM(LR, 98)* DRHOI* RC
185.      AM(1,I+3)=AM(1,I+3)-0.5*RC*YDS+C7*DUM*F(2,I)
186.      IF(I-1) 20,20,25
187.      20 AM(1,3)=AM(1,3)-RC/RI*YDQD/12.
188.      GO TO 30
189.      25 CALL LIAD(-1,1,NETA-2+I,-RC/RI*YDQD/12.)

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190. 30 AM(1,1)=AM(1,1)-DUM*C7*F(2,1)*F(2,1)/ALPH
191.    MPJ=MAT1J+1+I
192.    DO 60 K=NUL, NSPM1
193.    IF(K) 40,40,35
194. 35 DUM=AM(LR,K+ 98)*DRHOI*RC
195. 40 IF(I=NETA) 50,55,50
196. 50 AM(1,MPJ)=AM(1,MPJ)+DUM
197.    GO TO 60
198. 55 CALL LIAD(K,1,1,DUM)
199. 60 MPJ=MPJ+MAT2J
200.    GO TO 32
201. 33 CONTINUE
202.    IF(I,GE,KAPPA) GO TO 67
203.    AM(1,1)=AM(1,1)+DEL*YDI+CRD*C56*RRD*QSD
204. 67 CONTINUE
205.    IF(I,EQ,KAPPA) AM(1,1)=AM(1,1)+CRD*C56*RRD*QSD+RK*YDI*DEL
206.    IF(I,LT,KAPPA) GO TO 69
207.    AM(1,1)=AM(1,1)+QIDK*RRD*CRD*C56
208. 69 CONTINUE
209.    INK=I+3
210.    AM(1,INK)=-QSD*RRD*CRD
211.    IF(I,EQ,KAPPA) AM(1,INK)=AM(1,INK)-QIDK*RRD*CRD
212.    IF(I,EQ,KAPPA+1) AM(1,INK)=-QID*RRD*CRD
213.    INK=INK+1
214.    DO 68 K=1,NSP
215.    INK=INK+MAT2J
216.    AM(1,INK)=-QSD*RRD*DRHOK(K-1)
217.    IF(I,EQ,KAPPA) AM(1,INK)=AM(1,INK)-QIDK*RRD*DRHOK(K-1)
218.    IF(I,EQ,NETA) CALL LIAD(K-1,1,1,-QIDK*RRD*DRHOK(K-1))
219. 68 CONTINUE
220. 32 CONTINUE
221.    IF(I,EQ,(KAPPA-1)) DELTA(1S)=SDY
222.    IF(KR(17)) 66,66,65
223. 65 WRITE (KOUT,640) RC,RR,SDY,RRP,RRPD,RRFD,YDI,YDS,DUM1,DUM2,DVS
224.    1,YDIQ,YDQD,QI,GS,DRHOI,(AM(LR,K+ 98),K=NUL,NSPM1),
225.    2(AM(1,J), J=1,NNLEQ), ENL(1)
226. 66 LR=MAT1J+1
227.    DVS=AMAX1(0.,RC*DVS)
228.    IF(CBECK.GT.0.) GO TO 18
229.    AM(1,MAT1J)=AM(1,MAT1J)+SDY*RC
230. 18 CONTINUE
231.    DELTA(1S)=DELTA(1S)+RK*(SDY-DELTA(1S))
232.    DELTA(1S)=DELTA(1S)*DEL*ALPH
233.    RETURN
234. 75 RC=-RC
235.    DVS=0.
236.    DO 80 I=2,NETA
237.    CALL TAYLOR(DETA(I-1),F(2,I-1),F(2,1),XP)
238.    DVS=DVS+(F(2,1)*XP(1)+F(3,1)*XP(2)+F(4,1)*XP(3)+F(4,I-1)*XP(4))
239.    IFP=I+3
240.    IFPP=NETA+I-2
241.    IFPPP=IFPP+NETA
242.    AM(1,IFP)=XP(1)+AM(1,IFP)
243.    CALL LIAD(-1,1,IFPP,XP(2))
244.    CALL LIAD(-1,1,IFPPP,XP(3))
245.    CALL LIAD(-1,1,IFPPP-1,XP(4))
246. 80 CONTINUE
247.    DVS=DVS+RC/F(2,NETA)
248.    DO 85 I=1,NNLEQ
249. 85 AM(1,I)=-AM(1,I)*RC*2./F(2,NETA)
250.    AM(1,2)=AM(1,2)-RC
251.    AM(1,MAT1J)=AM(1,MAT1J)+DVS/F(2,NETA)
252.    CALL LIAD(-1,1,NETA-1,RC)
253.    DVS=AMAX1(RC*(F(1,NETA)-F(1,1))-DVS,0.)

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254. RETURN
255. 1003 CONTINUE
256. C26S = C26*C26
257. EPS2 = DVS/C26S
258. TURPR(I)=PRT
259. TURPR(I)=0.
260. IF(ELCON.LE.0.00001) GO TO 401
261. IF(IPRT.EQ.1) GO TO 505
262. IF(IWK.EQ.1) GO TO 401
263. IF(CCEB.GT.0..OR.CBECK.GT.0.) GO TO 505
264. C*** CALCULATES MIXING LENGTH AND ITS DERIVATIVES
265. 100 PIM=PI
266. PI=SQRT(ABS(RED/C26*(CAPC(1)*F(3,1)-ALPH*RHOVS*F(2,1))))/
267. 1 (CAPC(1)*YAP)
268. IF(I=1) 305,305,101
269. 101 EPI=EXP(-(PI+PIM)/2.*DETA(I-1))
270. PID=PI-PIM
271. IF(PID/PI-.0001) 102,102,103
272. 102 PI=AMAX1(PI,PIM)
273. PID=1.0
274. AF=1.0
275. ERP1=1./PI
276. ERPP1=-2./(PI*PI)
277. ERP2=1./PIM
278. ERPP2=-2./(PIM*PIM)
279. GO TO 104
280. 103 AF=SQRT(2./PID*DETA(I-1))
281. ERP1=ERP(AF/2.*PI)
282. ERPP1=1.-AF*PI*ERP1
283. ERP2=ERP(AF/2.*PIM)
284. ERPP2=1.-AF*PIM*ERP2
285. 104 BF=ERP1-EPI*ERP2
286. DCLL=EPI
287. DUM1=DETA(I-1)/2.*EPI*(AF*ERP2-CL)
288. CL=CL*EPI+AF*BF
289. EL(I)=ALPH*ELCON*(ETA(I)-CL)
290. DUM2=AF/PID*(BF/2.+ERPP1/4.*AF*PI-EPI*ERPP2/4.*AF*PIM)
291. DUM3=AF/2.*AF
292. DCLPI=DUM1-DUM2+DUM3*ERPP1
293. DCLPM=DUM1+DUM2-DUM3*ERPP2*EPI
294. IF(I=2) 305,330,320
295. 305 EL(I)=0.
296. DO 307 J=1,NNLEQ
297. 307 AM(2,J)=0.
298. CL=0.
299. DPI(1,2)= CAPC(1)
300. DPI(3,1)= F(3,1)*DCAPCH
301. IF(NSPM1) 350,350,310
302. 310 DO 315 K=1,NSPM1
303. 315 DPI(K+3,1)= F(3,1) * DCAPCK(K)
304. GO TO 350
305. 320 DO 325 J=1,NNLEQ
306. 325 AM(2,J)= AM(2,J) * DCLL
307. 330 DUM=-TREF*DCLPM*ELCON*ALPH
308. AM(2,1)= AM(2,1)+(EL(I)-DCLL*EL(I-1))/ALPH
309. L=I-1
310. 331 AM(2,1)= AM(2,1)+DPI(1,1)*DUM
311. AM(2,2)= AM(2,2) + DPI(2,1)* DUM
312. AM(2,3)= AM(2,3) + DPI(1,2)*DUM
313. AM(2,L+3)= AM(2,L+3)+DPI(2,2)*DUM
314. J=MAT1J+2
315. DO 340 K=NUL,NSPM1
316. AM(2,J)= AM(2,J) + DPI(K+3,1) * DUM
317. JL=J+L-1

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318.      AM(2,JL)= AM(2,JL) + DPI(K+3,2)*DUM
319.      J=J+MAT2J
320.      345 IF(L=1) 350,400,400
321.      350 TREF= RED/C26 /(2.*CAPC(I)*YAP*PI*YAP*CAPC(I))
322.      DPI(3,2)=-PI/TREF*(DCAPCH/CAPC(I)-DRHOW/(2.*RHO(I)))
323.      DPI(2,2)= C10*DPI(3,2)-RHOVS*ALPH
324.      DPI(1,1)=-C56*C10*DPI(3,2)-RHOVS*F(2,I)
325.      DPI(2,1)=-ALPH*C1*F(2,I)
326.      IF(NSPM1) 362,362,355
327.      355 DO 360 K=1,NSPM1
328.      360 DPI(K+3,2)=-PI/TREF*(DCAPCK(K)/CAPC(I)-DRHOK(K)/(2.*RHO(I)))
329.      362 L=I
330.      DUM=-TREF*DCLPI*ELCON*ALPH
331.      IF(I=1) 445,445,365
332.      365 IF(I-NETA) 331,400,400
333.      405 DEL=-VMUE(15)*C3
334.      INK=I-1
335.      ONK=-0.08333333
336.      IF(I=1)510,510,525
337.      510 INK=1
338.      ONK=ABS(ONK)
339.      C10W=C10
340.      C56W=C56
341.      TAUW=-UE(15)/ALPH*AMAX1(C26,+.0001)/C3
342.      DRHOW(1)=DRHOW
343.      DCAPW(1)=DCAPCH
344.      DO 515 K=1,NSPM1
345.      DRHOW(K+1)=DRHOK(K)
346.      515 DCAPW(K+1)=DCAPCK(K)
347.      DO 520 J=1,NNLEQ
348.      520 DYA(J)=0.
349.      CAPY=0.
350.      525 VA=DETA(INK)*C26*(.5-ONK*DETA(INK)*C53)
351.      CAPY=CAPY+VA
352.      DYA(1)=DYA(1)+VA*DEL
353.      IF(I.EQ.NETA) GO TO 532
354.      DYDRHO=-DETA(INK)/2.*C26/RHO(I)*ALPH*DEL
355.      VA=DYDRHO*DRHOW*C10
356.      DYA(1)=DYA(1)-VA*C56
357.      INK=I+3
358.      DYA(INK)=DYA(INK)+VA
359.      INK=INK+1
360.      DO 530 K=1,NSP
361.      INK=INK+MAT2J
362.      530 DYA(INK)=DYDRHO*DRHOK(K-1)+DYA(INK)
363.      IF(I.EQ.1) RETURN
364.      IF(ONK.GT.0.) GO TO 406
365.      ONK=ABS(ONK)
366.      532 CONTINUE
367.      UTAU=SQRT(TAUW/RHO(I))
368.      IF(CHECK.GT.0.) GO TO 700
369.      C ***** CEBECI-SMITH MODEL *****
370.      VWP=(F(1,1)*C1+HF(1,5))/(C3*UTAU*RHO(I))
371.      VA=YAP*VWP
372.      EXPV=EXP(VA)
373.      PPL=0.
374.      IF(ABS(BETA) .LT.1.E-07) GO TO 540
375.      PPL=-RHOE(15)/C3*UE(15)/C3*BETA*CAPC(I)/(RHO(I)*UTAU)**3
376.      540 CONTINUE
377.      EXPVM=EXPV-1.
378.      IF(ABS(VWP).LT.1.E-07) GO TO 533
379.      EXPVV=EXPVM/VWP
380.      GO TO 534
381.      533 EXPVV=YAP

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382. 534 CONTINUE
383. EXPVP=EXPVV*PPL
384. SQEXP=EXPVP+EXPV
385. IF(SQEXP.LE.0.0) SQEXP=1.0E-30
386. SQEXP=SQRT(SQEXP)
387. ACEB=CCEB*VMU(I)/RHO(I)/UTAU/SQEXP
388. ACY=ALPH*DEL*CAPY
389. YOA=ACY/ACEB
390. EXPA=EXP(-YOA)
391. EL(I)=ELCON*ACY*(1.-EXPA)
392. DLOY=ELCON*(1.-EXPA*(1.-YOA))
393. IF(INK.EQ.1) GO TO 555
394. DO 545 J=1,NNLEG
395. 545 AM(2,J)=DYA(J)*DLOY
396. DLDA=-ELCON*YOA**2*EXPA
397. DADRO=-1.5*ACEB/RHO(I)
398. DADC=ACEB/CAPC(I)
399. DADTA=-.5*ACEB/TAUW
400. IF(ABS(VWP).LT.1.E-07) GO TO 547
401. DADPP=-ACEB/2./VWP/(PPL/VWP+EXPV/EXPV)
402. DADVP=-ACEB/2.*(-EXPVP/VWP+YAP*(1.+PPL/VWP)*EXPV)/(EXPVP+EXPV)
403. GO TO 550
404. 547 DADPP=-ACEB/2./((PPL+1./YAP)
405. DADVP=DADPP*(1.+YAP*PPL/2.)
406. 550 CONTINUE
407. VAR=DRHOH*C10*C56
408. VAC=-DCAPCH*C10*C56
409. DADA=DADRO+VAR*2.*DADTA*TAUW/ALPH+DADPP*PPL*(VAC/CAPC(I)-
410. 11.5*VAR/RHO(I)+3./ALPH)+DADVP*VWP*(VAR/RHO(I)/2.+1./ALPH)
411. 2*DADC*VAC
412. AM(2,1)=AM(2,1)+DLDA*DADA
413. DADFW=DADVP*C1/C3/RHO(I)/UTAU
414. AM(2,2)=AM(2,2)+DLDA*DADFW
415. DADFWP=(DADTA*TAUW-1.5*DADPP*PPL-.5*DADVP*VWP)/F(3,1)
416. AM(2,3)=AM(2,3)+DLDA*DADFWP
417. INK=I+3
418. DADFP=DADRO*DRHOH*C10+DADPP*PPL*(DCAPCH*C10/CAPC(I)-
419. 11.5*DRHOH*C10/RHO(I))+DADVP*VWP*.5*DRHOH*C10/RHO(I)
420. 2*DADC*DCAPCH*C10
421. AM(2,INK)=AM(2,INK)+DLDA*DADFP
422. INK=INK+MAT2J+1
423. MINK=MAT1J+2
424. DADH=DADRO*DRHOH+DADPP*PPL*(DCAPCH/CAPC(I)-1.5*DRHOH/RHO(I))+
425. 1DADVP*VWP*.5*DRHOH/RHO(I)+DADC*DCAPCH
426. DCAPDC=DCAPCH(1)/CAPC(1)
427. DADHW=DADTA*TAUW*DCAPDC-DADPP*PPL*1.5*DCAPDC-
428. 1DADVP*VWP*.5*DCAPDC
429. AM(2,MINK)=AM(2,MINK)+DADHW*DLDA
430. IF(1.EQ.NETA) GO TO 552
431. AM(2,INK)=AM(2,INK)+DLDA*DADH
432. 552 IF(1.EQ.NETA) CALL LIAD(0,2,1,DADH*DLDA)
433. DO 551 K=2,N5P
434. INK=INK+MAT2J
435. MINK=MINK+MAT2J
436. DADK=DADRO*DRHOK(K-1)+DADPP*PPL*(DCAPCK(K-1)/CAPC(I)-
437. 11.5*DRHOK(K-1)/RHO(I))+DADVP*VWP*.5*DRHOK(K-1)/RHO(I)
438. 2*DADC*DCAPCK(K-1)
439. DCAPDC=DCAPCK(K)/CAPC(1)
440. DADKW=DADTA*TAUW*DCAPDC-DADPP*PPL*1.5*DCAPDC-
441. 1DADVP*VWP*.5*DCAPDC
442. AM(2,MINK)=AM(2,MINK)+DLDA*DADKW
443. IF(1.EQ.NETA) GO TO 553
444. AM(2,INK)=AM(2,INK)+DLDA*DADK
445. 553 IF(1.EQ.NETA) CALL LIAD(K-1,2,1,DLDA*DADK)

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446. 551 CONTINUE
447. CALCULATE THE TURBULENT PRANDTL NUMBER .....
448. 555 IF(IPRT,NE,1) GO TO 554
449. ADP=CCEB/SQEXP
450. BDP=CTPR/SQEXP
451. YPLUS=ACY*UTAU*RHO(I)/VMU(I)
452. YOAP=YPLUS/ADP
453. YOBP=YPLUS*SQRT(PR(I))/BDP
454. PRT=ELCON/TPCON*(1.-EXP(-YOAP))/(1.-EXP(-YOBP))
455. 554 TURPR(I)=PRT
456. IF(CCEB.GT.0.) GO TO 703
457. 700 CONTINUE
458. C ***** BECKWITH-BUSHNELL MODEL *****
459. SQPI=1.772453851
460. ABECK=CBECK/RHO(I)*VMU(I)/UTAU
461. ACY=ALPH*DEL*CAPY
462. VA=-ACY/ABECK
463. VB=DB*ACY/DELTA(IS)
464. VC=5.0*ACY/DELTA(IS)-3.90
465. EXPA=EXP(VA)
466. T1=1.-EXPA
467. T2=TANH(VB)
468. T3=SQRT(.5-.5*ERF(VC))
469. EL(I)=8BECK*DELTA(IS)*T1*T2*T3
470. DROR=1.5*DRHOH/RHO(I)
471. COSHB=COSH(VB)**2
472. EXPC=EXP(-VC**2)
473. DLDY=DELTA(IS)/ABECK*T2*T3*EXPA+DB*T1*T3/COSHB-2.5/SQPI*T1*T2/T3*
474. 1EXPC
475. DLDY=8BECK*DLDY
476. DLDA=-8BECK*DELTA(IS)*T2*T3*ACY/ABECK**2*EXPA
477. DLDEL=T1*T2*T3-DB*ACY/DELTA(IS)*T1*T3/COSHB+2.5/SQPI*T1*T2/T3*
478. 1ACY/DELTA(IS)*EXPC
479. DLDEL=DLDEL*8BECK
480. DO 701 J=1,NNLEQ
481. 701 AM(2,J)=DYA(J)*DLDY+AM(1,J)*DLDEL
482. DADA=ABECK*(C10+C56*(-DCAPCH/CAPC(I)+DROR)+1./ALPH)
483. AM(2,1)=AM(2,1)+DLDA*DADA
484. DADFWP=-ABECK/2./F(3,1)
485. AM(2,3)=AM(2,3)+DLDA*DADFWP
486. INK=I+3
487. DADFP=ABECK*C10*(DCAPCH/CAPC(I)-DROR)
488. AM(2,INK)=AM(2,INK)+DLDA*DADFP
489. INK=INK+MAT2J+1
490. MINK=MAT1J+2
491. DADH=ABECK*(DCAPCH/CAPC(I)-DROR)
492. DADHW=-.5*ABECK*DCAPCH(1)/CAPC(1)
493. AM(2,MINK)=AM(2,MINK)+DLDA*DADHW
494. IF(I.EQ,NETA) GO TO 702
495. AM(2,INK)=AM(2,INK)+DLDA*DADH
496. 702 IF(I.EQ,NETA) CALL LIAD(0,2,1,DLDA*DADH)
497. DO 707 K=2,N3P
498. INK=INK+MAT2J
499. MINK=MINK+MAT2J
500. DADK=ABECK*(DCAPCH(K-1)/CAPC(I)-1.5*DRHOK(K-1)/RHO(I))
501. DADKW=-.5*ABECK*DCAPCH(K)/CAPC(1)
502. AM(2,MINK)=AM(2,MINK)+DLDA*DADKW
503. IF(I.EQ,NETA) GO TO 708
504. AM(2,INK)=AM(2,INK)+DLDA*DADK
505. 708 IF(I.EQ,NETA) CALL LIAD(K-1,2,1,DLDA*DADK)
506. 707 CONTINUE
507. 703 CONTINUE
508. DO 704 J=1,NNLEQ
509. 704 AM(2,J)=AM(2,J)/C26/DEL
510. ELODEL=EL(I)/RHOE(IS)/DEL

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511.      AM(2,1)=AM(2,1)-DRHOH*C10+C56*ELODEL
512.      INK=I+3
513.      AM(2,INK)=AM(2,INK)+DRHOH*C10*ELODEL
514.      INK=INK+1
515.      DO 705 K=1,NSP
516.      INK=INK+MAT2J
517.      IF(I,EG,NETA) GO TO 706
518.      AM(2,INK)=AM(2,INK)+DRHOK(K-1)*ELODEL
519.      706 IF(I,EG,NETA) CALL LIAD(K-1,2,1,DRHOK(K-1)*ELODEL)
520.      705 CONTINUE
521.      EL(I)=EL(I)/C26/DEL
522.      IF(I,EG,NETA) GO TO 406
523.      INK=I
524.      GO TO 525
525.      C*** CALCULATES EPS1 AND EPS2 -- COMPARES TO GET EPS -- CALCULATES EPS
526.      C                                     DERIVATIVES
527.      406 IF(IWK,EG,1) GO TO 401
528.      400 DUM1=EL(I)/ALPH*EL(I)/ALPH*RED/C26
529.      EPS1=DUM1*ABS(F(3,I))
530.      IF(CHECK,GT,0.) GO TO 405
531.      IF(EPS1=EPS2) 405,401,401
532.      401 EPS=EPS2*VINTR(I)
533.      IWK=1
534.      ENL(3)=ENL(1)/C26S*VINTR(I)
535.      DO 402 J=1,NNLEQ
536.      402 AM(3,J)=AM(1,J)/C26S*VINTR(I)
537.      DUM1=2.0*EPS/RHO(I)
538.      GO TO 415
539.      405 EPS=EPS1*VINTR(I)
540.      ENL(3)=0.
541.      DO 410 J=1,NNLEQ
542.      410 AM(3,J)=2.*EPS / EL(I)*AM(2,J)
543.      AM(3,1)=AM(3,1)-2.0/ALPH*EPS
544.      CALL LIAD(-1,3,NETA+1-2,DUM1*VINTR(I)*F(3,I)/APS(F(3,I)))
545.      DUM1=EPS/RHO(I)
546.      415 DUM=DUM1*DRHOH
547.      EPSA(I)=EPS
548.      AM(3,1)=AM(3,1)-C56*C10*DUM
549.      AM(3,I+3)= AM(3,I+3)+DUM*C10
550.      J=MAT1J+I+1
551.      L=MAT1J
552.      DO 420 K=NUL,NSPM1
553.      IF(I-NETA) 418,416,416
554.      416 CALL LIAD(K,3,1,DUM)
555.      GO TO 419
556.      418 AM(3,J)=AM(3,J)+DUM
557.      419 J=J+MAT2J
558.      420 DUM=DUM1*DRHOK(K+1)
559.      DEPC=ENL(3)
560.      445 RETURN
561.      1004 CONTINUE
562.      C*** MODIFIES ENL AND AM AFTER IMONE
563.      L=I-1
564.      SALPH=-ALPH/TTVC
565.      IF(I-2) 650,650,600
566.      1005 CONTINUE
567.      C*** MODIFIES ENL AND AM AFTER IONLY

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B19A, TRMBL

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568.      L=I
569.      SALPH= ALPH/TTVC
570.      A00 IFPP=L+NETA-2
571.      ISPP=L
572.      DUM=F(3,L)/SALPH
573.      ENL(I+3)=ENL(I+3)-DUM*(EPS-DEPC)
574.      AM(I+3,1)=AM(I+3,1)-DUM*EPS/ALPH
575.      C28=C28+DUM*EPS
576.      DO 605 J=1,NNLEQ
577.      A05 AM(I+3,J)=AM(I+3,J)+DUM*AM(3,J)
578.      CALL LIAD(-1,I+3,IFPP,EPS/SALPH)
579.      MPJ=MAT1J+I-1
580.      PRF=1,-1./PRT
581.      EG1=G(2,L)/(SALPH*PRT)
582.      EG4=-PRF/SALPH*C13*F(2,L)
583.      EG3=EG4*EPS
584.      EG4=EG4+EG1
585.      EG2=EPS/SALPH*(1./SCT-1./PRT)*(HP-CPBAR(L)*TP)
586.      ENL(MPJ)=ENL(MPJ)-EG1*(EPS-DEPC)-EG2-EG3
587.      C32=C32+EG1*EPS+EG2+EG3
588.      AM(MPJ,1)=AM(MPJ,1)-EG1/ALPH*EPS-3.0/ALPH*EG3
589.      DO 610 J=1,NNLEQ
590.      A10 AM(MPJ,J)=AM(MPJ,J)+EG4*AM(3,J)
591.      AM(MPJ,L+3)=AM(MPJ,L+3)-PRF*C13/SALPH*EPS
592.      CALL LIAD(-1,MPJ,NETA+L-2,-PRF*C10/SALPH*EPS)
593.      CALL LIAD(0,MPJ,ISPP,EPS/(SALPH*PRT))
594.      IF(NSPM1) 650,650,615
595.      A15 DO 630 K=1,NSPM1
596.      DUM=SP(2,L,K)/(SALPH*SCT)
597.      MPJ=MPJ+MAT2J-1
598.      CK6(K)=CK6(K)+DUM*EPS
599.      ENL(MPJ)=ENL(MPJ)-DUM*(EPS-DEPC)
600.      AM(MPJ,1)=AM(MPJ,1)-DUM/ALPH*EPS
601.      DO 620 J=1,NNLEQ
602.      A20 AM(MPJ,J)=AM(MPJ,J)+DUM*AM(3,J)
603.      A30 CALL LIAD(K,MPJ,ISPP,EPS/(SALPH*SCT))
604.      A50 IF(KR(17)) 660,660,655
605.      A55 WRITE(KOUT,640) EPSOUT
606.      A40 FORMAT(/(1P10E12.5))
607.      A60 RETURN
608.      END

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B19B, ERF

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1.      C SUBROUTINE ERF  ERROR FUNCTION
2.      FUNCTION ERF(X)
3.      P=.47047
4.      A1=.3480242
5.      A2=-.0958798
6.      A3=.7478556
7.      T=1./(1.+P*ABS(X))
8.      XSQ=X*X
9.      ERF=1.-T*(A1+T*(A2+T*A3))*EXP(-XSQ)
10.     ERF=SIGN(ERF,X)
11.     RETURN
12.     END

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CB,9T

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1. SUBROUTINE TRANC
2. COMMON/COECOM/ C5,C6,C7,C8,C9,C10,C11,C12,C13,C14,C15
3. 1,C16,C17,C18,C19,C20,C21,C22,C23,C24,C25,C26,C27,C28,C29,C30,C31,C
4. 232,C33,C34,C35,C36,C37,C38,C39,C40,C41,C42,C43,C44,C45,C46,C47,C48
5. 3,C49,C50,C51,C52,C53,C54,C55,C56,C57,C58,C59,C60,C61,C62,C63,C64,C
6. 465,C66,C67,C68,C69,C70,C71,C72,C73,C74,C75,C76,C77,C78,C79,C80,C81
7. 5,C82,C83,C84,C85,C86,C87,C88
8. COMMON/COECON/ CK1( 6),CK2( 6),CK3( 6),CK4( 6),CK5( 6),CK6( 6)
9. 1,CK7( 6),CK8( 6),CK9( 6),CK10( 6),CK11( 6),CK12( 6),CK13( 6)
10. 2,CK14( 6),CK15( 6),CK16( 6),CK17( 6),CK18( 6),CK19( 6),CK20( 6)
11. 3,CK21( 6),CK22( 6),CKK1( 6, 6),CKK2( 6, 6),XM(5),XG(5),XSP(5, 7)
12. 4,CKK3( 6, 6)
13. COMMON/EDGCOM/ PE(40, 1),PTE(40, 1),SPE( 6,40, 1),DUES,
14. 1UE(40),RHOE(40),VMUE(40),TE(40),UEDGE,DUEEDGE,D2UEDG,VMWE,HE,C90
15. 2,DSIP(40),IDSIP,TTVC,TVCC(40),HEA(40),SF(20),CS(20),CSPR(20),
16. 3 CG(20),CGP(20),SREF,GEP,NEN
17. COMMON/ETACOM/ETA(15),DETA(15),DSO(14),DCU(14),B1(14),B2(14)
18. 1,LAR(123),BA1(43,18),BA2(30,15)
19. COMMON/HISCOM/C1,C2,C3,C4,ALPHD,BETA,ZM(4,14),ZG(4,14),ZSP(4,14, 6
20. 1 ),XI(40),HF(15,5),HG(15,3),HSP(15,3, 6),HALPH,HUE,MHUE,HFW,DLX2
21. 2,C3M(40),BETAM(40)
22. COMMON/INTCOM/ KR(20),KIN,KOUT,MAT1I,MAT2I,MAT1J,MAT2J,NETA,I,IS,N
23. 18,IT,NTIME,NSP,NSPM1,NAM,NLEQ,NNLEQ,NRNL, ITS,KAPPA,CBAR,CASE(15)
24. 2,B(8), MWE,NON,KQ(10),ITEM,NITEM,KR17,NBT,NBT2,IDENT,KR9(40)
25. 3,KAUXD,JTIME,JSPEC,MD(3)
26. COMMON/NONCOM/AH(123,123),DVNL(123),TCW,
27. 1VLNKH,DLPH( 7),DLPK( 6, 7),DTHW,DTKW( 6),FLUXJR( 7)
28. COMMON/PRMCOM/TIME( 50),PRE(40),PTET( 50),GE( 50),S(40),ROKAP(40)
29. 1,RNOSE,VKAP,NDISC,IDISC(40),NSD(5),MSD(5),ITF( 50),IPRE,RADNO,CONE
30. 2,RADFL( 50),RADR(40),RADS(40),IRAD
31. COMMON/PRPCOM/PR(15),T(15),RHO(15),SC(15),CAPC(15),QR(15),W(15)
32. 1,CPBAR(15),VMW(15),PHIK(15, 6),DRHCH,DRHOK( 6),ZK( 6),DZKH( 6), D
33. 2MU3K( 6),DMU4K( 6),DTK( 6),DPHKK( 6),DPRK( 6),DSCK( 6),DCAPCK( 6)
34. 3,DHTLK( 6),DGRK( 6),DCPBK( 6),DCPTK( 6),DMU12K( 6),DZKK( 6, 6)
35. 4,DPHKK( 6, 6), DMU4H,DMU3H,DHTILH,VMU12,CT,CTR,CPTIL,HTIL
36. 5,VMU3,DTH,DCAPCH,DPRH,DSCH,DGRH,DCPBH,DCPTH,DMU12H,VMU(15), RHDP
37. 6(15),PHIKP(15),HP,TP,ZKP( 6),VMU3P,VMU4P,HTILP,CRHO(14),GMR(15)
38. COMMON/TEMCOM/SPDUM( 6),DER(40),DUMM1(15),SLOPE(15),REDUM(15)
39. 1,SDUM1(40),SDUM2(40),FWDUM(40),XICON(40),FWCON(40),FWINIT( 1)
40. 2,XIINIT( 1),DUDS( 40)
41. COMMON/VARCOM/F(4,15),G(3,15),SP(3,15, 7),ALPH
42. ENTRY TVCEDG
43. LIM=1
44. IGH=1
45. IF(KR(6).GT.0)GO TO 35
46. SDUM1(1)=0.
47. SDUM2(1)=0.
48. DO 25 IS=2,NS
49. SDUM1(IS) = S(IS) * S(IS)
50. SDUM2(IS)=1.-ROKAP(IS)/S(IS)
51. LIM=IS
52. IF(IDISC(IS).EQ.1)GO TO 20
53. 25 CONTINUE
54. 20 CONTINUE
55. CALL SLOPL(LIM,SDUM1,SDUM2,DER,XICON)
56. DO 30 IS=2,LIM
57. DUM=1. - SDUM2(IS)
58. 30 TVCC(IS) = SQRT(4.*DER(IS)*(DUM-SDUM1(IS)*DER(IS))+ SDUM2(IS)/SDUM
59. 11(IS)*(1.+DUM))/DUM
60. TVCC(1) = SQRT(6.*DER(1))
61.

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62.      IF(LIM,GE,NS)GO TO 50
63.      IGH=LIM+1
64.      35 M=1
65.      IL=LIM+1
66.      DO 44 II=IL,NS
67.      M=M+1
68.      IF(IDISC(II).EQ.1)GO TO 301
69.      44 CONTINUE
70.      301 CALL SLOPL(M,S(LIM),ROKAP(LIM),DER(LIM),XICON(LIM))
71.      LIM=LIM+M-1
72.      IF(LIM,LT,NS)GO TO 35
73.      DO 45 IS=IGH,NS
74.      45 TVCC(IS) = SQRT(1.-DER(IS)*DER(IS))/ROKAP(IS)
75.      50 DO 55 IS=1,NS
76.      55 TVCC(IS)=-TVCC(IS)+2.*C3M(IS)*VMUE(IS)
77.      RETURN
78.      ENTRY TVCCOE
79.      CALLED IMMEDIATELY AFTER ICDEFF
80.      IF(I-1) 115,115,125
81.      115 RHS=0.
82.      DO 120 J=1,NNLEQ
83.      120 AM(4,J)=0.
84.      GO TO 130
85.      125 IND=I-1
86.      SIX=-6.
87.      GO TO 140
88.      130 IND=I
89.      SIX=6.
90.      C27=DRHOH
91.      DO 135 K=1,NSPM1
92.      135 CK11(K)=DRHOK(K)
93.      IF(I-1) 165,165,140
94.      140 DUM=DETA(I-1)/2. *RHOE(IS)/RHO(IND)
95.      IF(KG(9).LT.0) DUM=-DUM
96.      RHS=RHS+DUM*(1.+RHOP(IND)/RHO(IND)*DETA(I-1)/SIX)
97.      DUM=-DUM/RHO(IND)
98.      LPS=MAT1J+IND+1
99.      IF(NSPM1) 155,155,145
100.      145 LPI=LPS
101.      DO 150 K=1,NSPM1
102.      LPI=LPI+MAT2J
103.      150 AM(4,LPI)=AM(4,LPI)+DUM*CK11(K)
104.      155 DUM=DUM*C27
105.      AM(4,LPS) = AM(4,LPS) + DUM
106.      DUM=DUM*C7*F(2,IND)
107.      AM(4,IND+3) = AM(4,IND+3) + DUM
108.      AM(4,1)= AM(4,1)-DUM/ALPH*F(2,IND)
109.      IF(IND-I) 130,160,160
110.      160 TTVC=AMAX1(1.+RHS*ALPH*TVCC(IS),0.0001)
111.      165 RETURN
112.      ENTRY TVCM1
113.      CALLED IMMEDIATELY AFTER IMONE
114.      IND=I-1
115.      DUM1=-TVCC(IS)/TTVC
116.      GO TO 205
117.      ENTRY TVCI
118.      CALLED IMMEDIATELY AFTER EPSI
119.      IND=I
120.      DUM1=TVCC(IS)/TTVC
121.      205 DUM2=DUM1*C28
122.      DUM3=DUM1* C32
123.      AM(I+3,1)=AM(I+3,1)+DUM2*RHS
124.      M=MAT1J+I-1
125.      AM(M,1)=AM(M,1)+DUM3*RHS

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B19T, TRANC

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126.      DUM2=DUM2*ALPH
127.      DUM3=DUM3* ALPH
128.      DO 210 J=1,NNLEQ
129.      AM(I+3,J)=AM(I+3,J)+DUM2*AM(4,J)
130. 210 AM(M,J)=AM(M,J)+DUM3*AM(4,J)
131.      IF(NSPM1) 225,225,215
132. 215 DO 220 K=1,NSPM1
133.      DUM3=DUM1*CK6(K)
134.      M=M+MAT2J-1
135.      AM(M,1)=AM(M,1)+DUM3*RHS
136.      DUM3=DUM3*ALPH
137.      DO 220 J=1,NNLEQ
138. 220 AM(M,J) = AM(M,J) + DUM3*AM(4,J)
139. 225 RETURN
140.      END

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B20A, EQUIL

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1. CB20A
2. SUBROUTINE EQUIL(KQ,Z,PRR)
3. INTEGER FAMOA,FAMOB
4. EQUIVALENCE (TU(121),TF),(VNU,CIJ)
5. DIMENSION CIJ( 60,1),TF(1)
6. COMMON/TEMCOM/APE(14,14),BS(14),S1(14),S2(14),S3(14),S4(14),S5(14)
7. DIMENSION X(14),KQ(10),VLAM(123,1),GAMK(123,1),DQJRN(123,1)
8. EQUIVALENCE (AM(259),DQJRN(126),GAMK,VLAM)
9. COMMON /BLQCOM/FAMOA( 60),FAMOB( 60),N ,FR( 60,15),W(3),LEF( 8)
10. 1 ,LEFS( 8),PIEASE,LEFW( 8),L2,L3
11. COMMON/BUMCOM/ BUMP,CORMA,EASE,ICORM,MDOT,TFZ,I777,DTEMP,KIP,IX
12. COMMON/EDGCOM/ PE(40, 1),PTE(40, 1),SPE( 6,40, 1),DUES,
13. 1UE(40),RHOE(40),VMUE(40),TE(40),UEDGE,DUEDGE,D2UEDG,VMWE,CGE,C90
14. 2,DSIP(40),ID8IP,TVCC(40),HEA(40),SF(20),CS(20),CSPR(20),
15. 3CG(20),CGP(20),SREF,GEP,NEN,UINF,RHOINF,HINF,PINF
16. COMMON/EQPCOM/RB(60,3),RC(60,3),RD(60,3),RE(60,3),RF(60,3),RG(60,3)
17. 1),TU(60,3),FF(60),FFA,IFC(60),ATA(8),ATR(8),ATC(8),WAT(8),RA(60,3)
18. 3,
19. 2 KAT( 8),IR( 8),IS,KR(10),LAMI( 60),P,T,TK( 8, 8),VN( 60),
20. 3 VNU( 60, 8),ITPF,KR2,HCH,NCV,WM,WTH( 60),Y( 60),YM( 60),GG( 60)
21. 4 ,TQ( 8, 8),EPOVRK,SIGMA,BASMOL
22. COMMON /EQTCOM/SIP,HIP,EL,ENL,FLIQ,CPF,IRE,IER,AA,ITS,IN,IL,IT,
23. 1 MODE,HMELT,SMELT,TMAX,TMIN,MELT,SUMN,SUML,WS,WS8,B1,ISP2,ISPG,
24. 2 ISP,KKJ,SVA,SVB,SVC,SVD,SUMC,FFF,CMF,EP,RV,IFCJC,WTG,WTL,JC,HG,
25. 3 CPG,TTMIN,TTMAX,L7,L8,IB( 9),EB( 8),EBL( 8),A(14,14), B(14),
26. 4 IP( 60),ALP( 8),FNU( 8),GAMH( 8),GAMF( 8),SLAM( 8),DY( 60),RVS,
27. 5 CP( 60), H( 60),SB( 60),TC( 60),VLNK( 60),E( 60),PNUS( 8),
28. 6 BC( 8),BLNK( 8),BY( 8),IBC( 8),BE( 8),JJ( 4)
29. COMMON/FLPCOM/ LEFT( 8,2)
30. COMMON/FLXCOM/DELQW,DELJW( 6),WALLQ,WALLJ( 6),QW,VJKW( 7),TPHALL
31. COMMON /INTCOM/KKR(20),KIN,KOUT,MAT1I,MAT2I,MAT1J,MAT2J,NETA,II,
32. 1ISS,N3,ITT,NTIME,NSP,NSPH1,NAM,NLEQ,NNLEQ,NRNL,HITS,KAPPA,CBAR,
33. 2CASE(15),BB(8), MWE,NON,KD(10),ITEM,NITEM,KR17,NBT,NBT2,IDENT,
34. 3KR9(40),KAUXO,JTIME,JSPEC,MD(3),IU,ISH
35. COMMON/NONCOM/AM(123,123),DVNL(123),TCW,
36. 1VLNKW,DLPH( 7),DLPK( 6, 7),DTHW,DTKW( 6),FLUXJR( 7)
37. COMMON /PRPCOM/PR(15),TT(15),RHO(15),SC(15),CAPC(15),QR(15),WH(15)
38. 1,CPBAR(15),VMW(15),PHIK(15, 6),DRHOK,DRHOK( 6),ZK( 6),DZKH( 6), D
39. 2MU3K( 6),DMU4K( 6),DTK( 6),DPHIKH( 6),DPRK( 6),DSCK( 6),DCAPCK( 6)
40. 3,DHTLK( 6),DGRK( 6),DCPBK( 6),DCPTK( 6),DMU12K( 6),DZKK( 6, 6)
41. 4,DPHIKK( 6, 6), DMU4H,DMU3H,DHTILH,VMU12,CT,CTR,CPTIL,HTIL
42. 5,VMU3,DTH,DCAPCH,DPRH,DSCH,DGRH,DCPBH,DCPTH,DMU12H,VMU(15), RHOP
43. 6(15),PHIKP(15),HP,TP,ZKP( 6),VMU3P,VMU4P,HTILP,CRHO(14),GMR(15)
44. COMMON/VARCOM/F(4,15),G(3,15),SP(3,15, 7),ALPH
45. COMMON/WALCOM/FW(40, 1),TW(40, 1),HW(40, 1),SPW( 6,40, 1)
46. 1,RHOVW(40, 1),FLUXJ( 3,40, 1),IHW,ITW,IFW,ISPW,IRHOVW,IFLUXJ
47. EQUIVALENCE(B,X)
48. COMMON/UNICOM/UCD,UCE,UCL,UCM,UCP,UCR,UCS,UCT,UCV,ITDK
49. 1 ,IUNIT,IPLT,KA(2,19)
50. 1 FORMAT(10I1,3F10,5)
51. 2 FORMAT(5X,6HTEMP =F10,4,1X,A6,5X,6HPRES =1PE10.3,1X,A6,5X,
52. 1 9HMOL WT = ,F11,7)
53. 3 FORMAT( /8TH SPECIES PAR,PRES. D-LOG-PP LOG-PP LO
54. 1G-KP FLAG ERROR CP /(1X2A4,4E13.5,15,2E13.5))
55. 4 FORMAT(/10X33H CP-FROZEN CP-EQUIL GAMMA ,
56. 1 /13X,A6,7X,A6,/9X3E12,5)
57. 7 FORMAT(I3,F8.2,11E10.3/91X3E10.3)
58. 8 FORMAT(10X10HENTHALPY =E14,7,1X, A6 ,11H ENTROPY =E12.5,1X,A6 ,/
59. 1 10X,9HDENSITY =E13.6,1X,A6)
60. 6 FORMAT(//)
61. 9 FORMAT(5X5HVEL =1PE10.3,1X,A6 ,10H MACH NO.=1PE10.3)

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62.      10 FORMAT(10X17HFRACTION LIQUID =F8.5)
63.      42 FORMAT(8F10.4)
64.      DTU=500.
65.      DTD=DTU
66.      LEFUP=1
67.      TTMIN=50.0
68.      TTMAX=100000.
69.      IQQ=0
70.      MELT=1
71.      FLIQ=0.
72.      HMELT=0.
73.      ITS=0
74.      IG=0
75.      INV=0
76.      SPEASE=PIEASE
77.      TION=1500.
78.      ISP=IS+1
79.      DO 302 I=1,6
80. 302   KR(I)=KG(I)
81.      MODE=KR(1)
82.      IF(KR(5).NE.3)P=PRR
83.      KKJ=0
84.      KR(8)=0
85.      KR(6)=KR(6)-1
86.      IF(KKR(18)=6) 3021,3021,3022
87. 3021  KR(7)=KKR(18)*5-9
88.      N7=51-KKR(18)*5
89.      GO TO 3023
90. 3022  KR(7)=0
91.      N7=KKR(18)*10-50
92. 3023  IF(KR(5)=1) 310,304,306
93.  C*****ISENTROPIC EXPANSION
94. 304   SIP=SIP-DSIP(ISS)
95.      IEW=2
96.      II=NETA
97.      IF(MODE.NE.2) GO TO 324
98.      HIP=Z/1.8
99.      GO TO 324
100.  C*****STAGNATION POINT AND INITIALIZATION
101. 306   IF(KR(5).EQ.3) GO TO 307
102.      KR(8)=0
103.      ITFF=0
104.      PIEASE=0.
105.      KG(6)=0
106.      HIP=Z/1.8
107.      MITS=1
108.      II=NETA
109.      VMW(NETA)=VMWE
110.      T=3000.
111.      WM=20.
112.      AAP=WM
113.      DO 309 I=1,IS
114. 309   ALP(I)=TQ(I,1)
115.      KR(6)=1
116.      IF(ITEM=1) 350,308,350
117. 308   IF(KKR(2)=2) 311,350,311
118. 310   IF(KR(6)) 312,330,330
119. 311   LEFUP = -1
120.      IF (KKR(12)=1) 384,350,384
121.  C*****SHOCK ENTROPY CALCULATION
122. 307   SA1=Z
123.      KKJ=-1
124.      SVA=(1.3146*RHOINF*UINF*COS(SA1))**2/90108.
125.      SVB=SVA*2./1.9869

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126. SVC=(UINF+COS(SA1))*2/90.08.*HINF
127. SVD=PINF+SVB/(1.3146+RHOINF)
128. IF(SA1.GT.0.0001)GO TO 324
129. P=PTE(1,1)
130. T=TCH
131. GO TO 324
132. C*****BOUNDARY LAYER
133. 312 DO 3120 K=NSP,18
134. 3120 ALP(K)=0.
135. LEFUP=MITS+II-2
136. HIP=Z/1.8
137. ALP(NSP)=1.0
138. IF(NSPM1) 3141,3141,313
139. 313 DO 314 K=1,NSPM1
140. ALP(K)=SP(1,II,K)/WTM(K)
141. 314 ALP(NSP)=ALP(NSP)-SP(1,II,K)
142. 3141 ALP(NSP)=ALP(NSP)/WTM(NSP)
143. DO 319 I=1,18
144. IF(KAT(I).EQ.99) GO TO 319
145. ARPH=0.
146. ARPHM=0.
147. DO 315 K=1,NSP
148. DUM=CIJ(I,K)*ALP(K)
149. ARPHM=AMAX1(ARPHM,ABS(DUM))
150. 315 ARPH=ARPH+DUM
151. IF(II.EQ.1.AND.LEFH(I).EQ.1.AND.LEF(I).LE.0) LEF(I)=1
152. IF(ARPH=.0001*ARPHM) 316,316,319
153. 316 IF(II.EQ.1.AND.LEF(I).EQ.1) LEF(I)=0
154. LEF(I)=-IABS(LEF(I))
155. LEFS(I)=-IABS(LEFS(I))
156. 319 CONTINUE
157. 320 IF(ITFF) 326,350,350
158. C*****ACCEPT RESIDENT VALUES AS FIRST GUESSES
159. 324 IF(T-TION) 328,398,398
160. 326 ITFF=ITFF+1
161. IF(II-1) 323,323,322
162. 322 IG=1
163. GO TO 350
164. 323 IF (ITFF) 327,329,329
165. 327 IF(KR2-1) 328,329,328
166. 329 GO TO 350
167. 328 IF(KAT(18).EQ.99) LEF(18)=-IABS(LEF(18))
168. IF(LEFUP) 393,364,393
169. C*****WALL SOLUTION
170. 330 IEW=1
171. ITFF=-1
172. II=1
173. CHFLUX=W(3)
174. PIEASE=PIEASE+0.989*(1.0-EASE)
175. KR(7)=MAX0(KR(7),KKR(16)*5-4)
176. IF(TT(1)/1.8.GT.TF(N+1)) KR(8)=1
177. IF(MODE=1) 333,331,333
178. 331 TTMIN=TT(1)/1.8-500.
179. TTMAX=TT(1)/1.8+500.
180. KR(8)=0
181. 333 IF(KR(8).EQ.1) CHFLUX=-1.
182. DO 332 K=1,18
183. IF(LEF(K)) 332,3331,332
184. 3331 IF(W(2)*TK(K,L2)+CHFLUX*TK(K,L3).LT.0.) LEF(K)=1
185. 332 ALP(K)=TQ(K,L2)*AMIN1(0.,W(2))+TQ(K,L3)*AMIN1(0.,W(3))+TQ(K,1)*
186. 1 AMIN1(0.,W(1))
187. WS=-W(1)-W(2)-W(3)
188. WSS=-AMIN1(0.,W(1))-AMIN1(0.,W(2))-AMIN1(0.,W(3))
189. DO 335 L=NSP,18

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190.      DO 334 K=1,IS
191.      GAMK(K,L)=0.
192.      334 GAMK (L,K)=0.
193.      GAMH(L)=0.
194.      335 GAMF(L)=0.
195.      IF(NSPM1) 3361,3361,3351
196.      3351 DO 336 K=2,NSP
197.      GAMH(NSP)=GAMH(NSP)-DQJRN(2,K)/WTM(NSP)*1.8
198.      GAMF(NSP)=GAMF(NSP)-DQJRN(1,K)/WTM(NSP)
199.      ALP(NSP)=ALP(NSP)+WALLJ(K-1)/WTM(NSP)
200.      ALP(K-1)=ALP(K-1)-WALLJ(K-1)/WTM(K-1)
201.      GAMH(K-1)=DQJRN(2,K)/WTM(K-1)*1.8
202.      GAMF(K-1)=DQJRN(1,K)/WTM(K-1)
203.      DO 336 KK=2,NSP
204.      336 GAMK(KK-1,NSP)=GAMK(KK-1,NSP)-GAMK(KK-1,K-1)
205.      3361 DO 3362 K=1,IS
206.      DO 3362 J=ISP,N
207.      3362 VLAM(J,K)=WS*WTM(J)*GAMF(K)
208.      C BINARY DIFFUSION SET UP
209.      IF(IS.LE.NSP) GO TO 3364
210.      NSPP=NSP+1
211.      DO 3363 K=NSPP,IS
212.      GAMK(K,K)=1.0
213.      DO 3363 J=ISP,N
214.      3363 VLAM(J,K)=VNU(J,K)
215.      3364 DUM1=NSPM1
216.      DO 340 K=1,NSP
217.      GAMH(K)=GAMH(K)
218.      SUMG=0.
219.      IF(NSPM1) 3392,3392,3391
220.      3391 DO 339 KK=1,NSP
221.      IF(KK=K) 337,339,337
222.      337 SUMG=SUMG+GAMK(KK,K)
223.      339 CONTINUE
224.      SUMG=SUMG/DUM1
225.      ALP(K)=ALP(K)+SUMG/WTM(K)
226.      3392 DO 338 KK=1,NSP
227.      338 GAMK(KK,K)=-(GAMK(KK,K)-SUMG)/WTM(K)*WTM(KK)
228.      DO 340 KK=1,NSP
229.      DO 3401 J=ISP,N
230.      3401 VLAM(J,K)=VLAM(J,K)+GAMK(KK,K)*VNU(J,KK)
231.      340 GAMK(KK,K)=GAMK(KK,K)+WTM(KK)*GAMF(K)*WS
232.      C*****RECALL STORED VALUES OF BOUNDARY LAYER SOLUTION AND
233.      C RE-INITIALIZED OMITTED SPECIES
234.      350 IF (YT(II).LE.0.0) IG=1
235.      II=II-IG
236.      PIN=1.E-4*P
237.      PINL=ALOG(PIN)
238.      LIM=N+KR(8)
239.      DO 354 I=1,LIM
240.      IF(IFC(I)=1) 342,342,341
241.      341 IFC(I)=IFC(I)-3
242.      GO TO 345
243.      342 IF(IFC(I)+1) 343,345,345
244.      343 IFC(I)=IFC(I)+3
245.      345 IF (IFC(I)) 346,349,346
246.      346 VN(I)=FR(I,II)*P
247.      IFC(I)=1
248.      Y(I)=0.
249.      IF(VN(I)) 347,347,354
250.      347 IFC(I)=1
251.      IF (I=IS) 348,348,354
252.      348 Y(J)=PINL
253.      GO TO 3530

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254. 349 IF(FR(I,II))357,357,352
255. 357 IF(VN(I)) 351,351,358
256. 358 IF(II-1) 353,351,353
257. 351 VN(I)=PIN
258. GO TO 353
259. 352 VN(I)=FR(I,II)*P
260. 353 Y(I)=ALOG(VN(I)+1.E-35)
261. 3530 IF(II-1) 354,3531,354
262. 3431 IF(IS-I) 354,3532,3532
263. 3432 Y(I)=YW(I)
264. IF(FR(I,1)=1.E-30) 354,3533,354
265. 3433 VN(I)=EXP(Y(I))
266. 354 CONTINUE
267. T=TT(II)/1.8
268. IF(T.GT.TION.OR.KAT(IS).NE.99) GO TO 356
269. LEF(IS)=IABS(LEF(IS))
270. 356 WM=VMW(II)
271. II=II+IG
272. IF(LEFUP) 364,364,393
273. C*****REEVALUATE ABSENT ATOM ARRAY
274. 364 JT=MOD(ITEM,2)+1
275. DO 382 K=1,IS
276. LEFW(K)=0
277. LEFS(K)=LEF(K)
278. LEF(K)=ISIGN(LEFT(K,JT),LEF(K))
279. IF(LEF(K)=2) 369,365,382
280. 365 IF(IU-1)369,369,367
281. 367 IF(KKR(3)) 369,369,382
282. 369 LEF(K)=MIN0(LEF(K),0)
283. IF(KKR(9)=2) 370,382,381
284. 370 DUM1=1.0
285. DUM2=0.
286. IF(NSPM1) 3721,3721,3701
287. 3701 DO 372 J=1,NSPM1
288. DUM1=DUM1-SPW(J,ISS,ITT)
289. 372 DUM2=DUM2+SPW(J,ISS,ITT)*CIJ(K,J)
290. 3721 IF(ABS(DUM1)-1.E-7) 376,374,374
291. 374 DUM2=DUM2+DUM1*CIJ(K,NSP)
292. 376 IF(DUM2) 382,382,380
293. 380 LEF(K)=1
294. GO TO 382
295. 381 IF(W(2)*TK(K,L2)+W(3)*TK(K,L3).LT.0.) LEFW(K)=1
296. 382 CONTINUE
297. GO TO 393
298. C*****INITIALIZE SP(,,) AND VN() ON FIRST STAGNATION SOLUTION
299. 384 ITFF=-NETA
300. NCV=0
301. TT(1)=3000.
302. VMW(1)=20.
303. KR2=KKR(2)
304. IF(KR2.LT.0) KR2=1
305. IF(KR2.EQ.1) GO TO 387
306. 385 DO 386 K=1,NSP
307. DO 386 I=1,NETA
308. SP(1,I,K)=ALP(K)*WTH(K)
309. SP(2,I,K)=0.
310. 386 SP(3,I,K)=0.
311. W(1)=0.
312. W(2)=0.
313. W(3)=0.
314. DO 3868 I=1,IS
315. IF(KAT(I).EQ.99) GO TO 3867
316. LEF(I)=0
317. IF(TK(I,1)) 3868,3868,3867

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318. 3867 LEF(I)=3
319. 3868 CONTINUE
320. 387 DO 388 I=1,13
321. IF(ALP(I)) 393,388,388
322. 388 CONTINUE
323. DO 3881 J=1,N
324. SB(J)=0.
325. H(J)=0.
326. DO 3881 I=1,NETA
327. 3881 FR(J,I)=0.
328. DO 392 I=1,13
329. VN(I)=AMAX1(VN(I)/P*.1,ALP(I)*AA)
330. IF(IFC(I)) 390,391,390
331. 390 IFC(I)=1
332. Y(I)=0.
333. GO TO 392
334. 391 Y(I)=ALOG(VN(I))
335. 392 CONTINUE
336. C*****DELETE MOLECULES BASED ON ABSENT ATOM ARRAY
337. 393 LAMD=1
338. DO 3971 K=1,13
339. IF(LEF(K)) 394,3930,3934
340. 3934 IF(PIEASE=.99) 3931,3931,3933
341. 3930 IF(PIEASE=.01) 394,394,3933
342. 3933 IF(LEFS(K)) 3932,394,3931
343. 3931 IF(II=NETA) 397,3932,397
344. 3932 IF(LEF(K)=3) 394,397,394
345. 394 DO 396 J=1,N
346. IF(IABS(IFC(J))=1) 389,389,396
347. 389 IF(MOD(LAMI(J)/LAMD,2)) 395,396,395
348. 395 VN(J)=0.
349. IFC(J)=IFC(J)-3
350. 396 CONTINUE
351. J=-IR(K)
352. IF(IFC(J)=1) 3961,3961,397
353. 3961 IFC(J)=IFC(J)+6
354. 397 LAMD=LAMD+LAMD
355. LEF(K)=IABS(LEF(K))
356. 3971 LEFS(K)=IABS(LEFS(K))
357. C*****DELETE CONDENSED SPECIES FROM BOUNDARY LAYER
358. IF(KR(6)) 3980,398,398
359. 3980 DO 3984 J=1,N
360. IF(IABS(IFC(J))=1) 3984,3981,3984
361. 3981 IFC(J)=IFC(J)-3
362. VN(J)=0.
363. 3984 CONTINUE
364. 398 IF(KR(7)=1) 21,21,1902
365. C*****EVALUATE PROPERTIES
366. 170 CPF=CPF/AA
367. IF(KR(5),EQ,3) GO TO 19
368. HG=0.
369. HL=0.
370. WTL=0.
371. SIP=0.
372. DO 1703 J=1,N
373. SIP=SIP+VN(J)*(SB(J)-1.9869+Y(J))
374. IF(IFC(J)) 1703,1704,1705
375. 1704 HG=HG+VN(J)*H(J)
376. GO TO 1703
377. 1705 HL=HL+VN(J)*H(J)
378. WTL=WTL+VN(J)*WTM(J)
379. 1703 CONTINUE
380. SIP=SIP/AA
381. HIP=(HG+HL)/AA

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382. IF(KR(6)) 1701,1932,1702
383. 1702 RV=RVS+(RV-RVS)/EASE
384. IF(KR(8),GT,0) W(3)=W(3)-VN(N+1)/AA
385. WS=W(1)-W(2)-W(3)+1,E=30
386. HIP=(HG+(HL-WTL/AA*HG)/WS)/AA
387. GO TO 1932
388. 1701 IN=IS+2
389. IG=MIN0(IQQ,-KKR(20))
390. CALL RERAY(IN,A,0.8,0,0,IG,14,S1,S2,S3,S4,S5)
391. ALF=A(2,1)/A(1,1)
392. CSP=1./(A(1,1)*AA)
393. BETH=P*(A(2,2)-A(1,2)*ALF)-1.
394. IF(MODE=3) 1931,1932,1931
395. 1931 CSP=CSP/T
396. 1932 CALL PROPS
397. WM=AA/P
398. GAM=1.-ALF
399. GAM=1./(1.+BETH-1.9869/AA*GAM/CSP*GAM*P)
400. GMR(II)=GAM
401. IF(KR(5))195,195,194
402. 195 IF(KR(7)) 11,11,194
403. 194 UCET=UCT/UCF
404. VA=CPF*UCET
405. VB=CSP*UCET
406. L=IUNIT+1
407. WRITE(KOUT,4) KA(L,4),KA(L,4),VA,VB,GAM
408. ITS=-1
409. C*****OUTPUT PACKAGE
410. 19 WM=AA/P
411. 1902 VA=P/UCF
412. WRITE(KOUT,2)T,KA(L,5),VA,KA(L,2),WM
413. 1901 FORMAT(5X40HRELATIVE MASSES OF COMPONENTS 1,2 AND 3 3E12.5)
414. SHIP=HIP
415. SSIP=SSIP
416. HIP=0.
417. SIP=0.
418. DO 20 J=1,N
419. HIP=HIP+H(J)*SIGN(VN(J),WTM(J))
420. 20 SIP=SIP+ VN(J)*(SB(J)-1.9869*Y(J))
421. N=N+KR(8)
422. HIP=(HIP+VN(MELT)*FLIQ*HMELT)/AA
423. SIP=(SIP+VN(MELT)*FLIQ*SMELT)/AA
424. RHR=P/T*WM/1.3146
425. VA=HIP*UCET
426. VB=SIP*UCET
427. VC=RHR/UCD
428. WRITE(KOUT,8)VA,KA(L,6),VB,KA(L,4),VC,KA(L,8)
429. IF(FLIQ) 204,205,204
430. 204 WRITE(KOUT,10) FLIQ
431. 205 IF(ITS) 2051,203,203
432. 2051 IF(KR(5)=1) 203,202,201
433. 201 IF(KR(5),EQ,2)GO TO 200
434. Z=SSIP
435. GO TO 203
436. 200 HCH=HIP
437. TCH=T
438. SREF=SSIP
439. 202 VELSQ=(HCH-HIP)*2.
440. VMACH=SQRT(VELSQ/GAM*WM/(1.9869*T))
441. VEL=SQRT(VELSQ*45054.)
442. UE(1SS)=VEL
443. MEA(1SS)=1.8*HIP
444. IF (VEL) 2021,2021,2022
445. 2021 AREA=0.

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B20A, EQUIL

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446.      GO TO 2023
447.      2022 AREA=1./(VEL+RHR)
448.      2023 VA=VEL/UCL
449.      WRITE(KOUT,9)VA,KA(L,7),VMACH
450.      203 IF(IQO) 2036,1203,1203
451.      1203 IF(ITS) 2031,2036,2036
452.      2031 DO 2033 I=1,N
453.      2033 VN(I)=VN(I)/P
454.      WRITE(KOUT,2032)(FAMOA(I),FAMOB(I),VN(I),I=1,N)
455.      DO 2035 I=1,N
456.      2035 VN(I)=VN(I)*P
457.      IF(MODE=1) 2034,2037,2034
458.      2037 WRITE(KOUT,2038) FAMOA(JC),FAMOB(JC)
459.      2038 FORMAT(22H SURFACE SPECIES IS 2A4)
460.      2032 FORMAT(/3(5X7HSPECIES3X8HMOLE FR,2X)/(5X2A4,E12.5,5X2A4,E12.5,5X2A
461.      14,E12.5))
462.      GO TO 2034
463.      2036 WRITE(KOUT,3) (FAMOA(I),FAMOB(I),VN(I),DY(I),Y(I),VLNK(I),IFC(I),E
464.      1(I),CP(I),I=1,N)
465.      2034 WRITE(KOUT,6)
466.      N=N-KR(8)
467.      IF(ITS) 11,1021,1021
468.      1021 HIP=SHIP
469.      SIP=SSIP
470.      C*****PRINCIPAL ITERATIVE LOOP
471.      21 IF(ITS) 109,110,109
472.      109 IF(MODE) 111,111,110
473.      1091 ITS=ITS+1
474.      110 CALL THERM
475.      111 MODE=KR(1)
476.      IQO=0
477.      FLIQ=0.
478.      CALL MATER
479.      B1=B(1)
480.      211 MOE=1
481.      IF(KR(7)=1) 2101,210,2102
482.      2102 IQO=-2
483.      WRITE(KOUT,2100)(I,I=1,IS)
484.      210 WRITE(KOUT,7) ITS,T,AA,EL,ENL,CMF,(E(I),I=1,IS)
485.      2100 FORMAT (50HITS TEMP PRES*MWT EQUIL ER MASBAL ER SCALE 7(I3,
486.      17H MASBAL)/90X3(I3,7H MASBAL))
487.      2101 IF(ITS) 2103,221,221
488.      2103 IF(MODE=1) 170,2104,170
489.      2104 TWALG=T
490.      GO TO 170
491.      221 ITS=ITS+1
492.      IF(ITS=50) 2219,2219,222
493.      2219 IF(ITS=N7) 22,2222,2222
494.      222 IF(KKR(18)) 2226,2226,2225
495.      2225 WRITE(KOUT,2000)
496.      2000 FORMAT (///2X,50H-----FOLLOWING OUTPUT NON-CONVERGENT-----
497.      1-/70H ISS,ITEM,II,MITS,ITS,IQO,KR(6),HIP,SIP,TT(II)/ALP(I)/LEF(I)
498.      2/FR(I,II))
499.      WRITE(KOUT,3017)ISS,ITEM,II,MITS,ITS,IG,KR(6),HIP,SIP,TT(II)
500.      WRITE(KOUT,3018) ALP
501.      WRITE(KOUT,3019) LEF
502.      WRITE(KOUT,3018) (FR(I,II),I=1,N)
503.      3017 FORMAT(7I5,2X1P3E12.5)
504.      3018 FORMAT(2X1P10E11.4)
505.      3019 FORMAT(2X10I5)
506.      IQO=-2
507.      KR(7)=1
508.      2226 ITS=1
509.      NCV=NCV+1

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B20A, EQUIL

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510.      NON=NCV
511.      IF(NCV=20) 170,170,2220
512. 2220 MITS=100
513.      GO TO 170
514. 2222 KR(7)=3
515.      IQQ=-2
516.      GO TO 22
517.      22 ISPQ=IN+IL-1
518.      ICT=10
519.      DUM1=0.
520.      DO 2205 I=1,ISPQ
521. 2205 B3(I)=B(I)
522.      GO TO 2208
523. 2207 DO 2206 I=IL,ISPQ
524. 2206 B(I)=B3(I)
525. 2208 DO 2204 I=1,ISPQ
526.      DO 2200 J=1,ISPQ
527. 2200 APE(I,J)=A(I,J)
528.      IF(I=2) 2204,2204,2201
529. 2201 IF(IFC(I-2)=1) 2204,2204,2202
530. 2202 B(I)=0.
531.      DO 2203 J=1,ISPQ
532.      APE(J,I)=0.
533. 2203 APE(I,J)=0.
534.      APE(I,I)=1.0
535. 2204 CONTINUE
536.      IG=IQQ
537.      CALL RERAY(IN,APE(IL,IL),0,B(IL),1,0,IG,14,S1,S2,S3,S4,S5)
538.      ICT=ICT-1
539.      IF(ICT=IQQ) 222,2209,2210
540. 2209 IQQ=-2
541. 2210 IF(IG) 2212,2221,2221
542. 2212 IF(INV) 2216,2213,222
543. 2213 IF(KR(6)) 2227,2230,2230
544. 2230 LAMD=1
545.      DO 2229 K=1,IS
546.      J=-IR(K)
547.      IF(IFC(J).GT.1) GO TO 2229
548.      DO 2228 J=1,N
549.      IF(VN(J).GT.1.E-30 .AND. MOD(LAMI(J)/LAMD,2).NE.0) GO TO 2229
550. 2228 CONTINUE
551.      LEF(K)=-IABS(LEF(K))
552.      LEFW(K)=-IABS(LEFW(K))
553.      INV=-1
554.      ITS=1
555.      GO TO 393
556. 2229 LAMD=LAMD+LAMD
557. 2227 INV=-1
558.      PIN=P+1.E-5
559.      DO 2215 I=1,N
560.      IF(IFC(I)) 2215,2214,2215
561. 2214 VN(I)=VN(I)+PIN
562.      Y(I)=ALOG(VN(I))
563. 2215 CONTINUE
564.      GO TO 111
565. 2216 IF(KR(6)) 2217,222,222
566. 2217 ITS=999
567.      GO TO 111
568. C****IF TRYING TO PUSH THROUGH TMIN OR TMAX == REINVERT AND DT TO ZERO
569. 2221 IF(T-TMIN) 2223,227,220
570. 2223 T=TMIN
571.      GO TO 1091
572. 227 IF (X(1)) 228,220,220
573. 220 IF (T-TMAX) 223,229,2224

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B20A, EQUIL

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574. 2224 T=TMAX
575. GO TO 1091
576. 229 IF(X(1)) 223,223,228
577. C*****IF NEW CONDENSED HAS NEG CORRECTION, DELETE AFTER REINVERT
578. 223 IF(IER) 226,212,226
579. 226 IF(X(IER)+1.E-4) 225,212,212
580. 225 DO 2252 I=1,ISPQ
581. A(IER,I)=0.
582. 2252 A(I,IER)=0.
583. BS(IER)=1.E-8
584. A(IER,IER)=1.0
585. GO TO 2207
586. C*****IF S.E. ERROR AND CORRECTION ON T OF CONFLICTING SIGN, REINVERT
587. 212 IF(MODE=1) 224,213,224
588. 213 IF(X(1)+B1+.00001) 228,218,218
589. C*****ON S.E. IF DELTA LN T .GT. .9 REINVERT NO DT IF EL AND ENL ARE SMA
590. 218 IF(ABS(X(1))-0.9)224,224,228
591. C*****IF CONVERGED EXCEPT FOR T ON H OR S OPTIONS -- NON CONVERGENT
592. 228 IF(MODE=1) 2281,214,2280
593. 2280 IF(EL+100.*ENL-1.E-4) 222,222,2281
594. C*****ON S.E. OPTION RESULT IN CONFLICTING ERROR/CORRECTION OR T PUSH
595. C*****IF OTHER BALANCES RELATIVELY GOOD, SET T TO TMIN/TMAX AS PER ERROR
596. C*****AND GO TO THERM (IF T ALREADY THERE - NONCONVERGE) ELSE DT TO ZERO
597. 214 IF(ABS(B1)=100.*(EL+ENL)) 2281,215,215
598. 215 TTMIN=TT(1)/1.8-500.
599. TTMAX=TTMIN+1000.
600. IF(B1) 216,216,217
601. 216 IF(T-TMIN) 170,170,2161
602. 2161 T=AMAX1(T-DTU,TMIN)
603. TTMAX=T
604. DTU=DTD/2.
605. GO TO 1091
606. 217 IF(T-TMAX) 2171,170,170
607. 2171 T=AMIN1(TMAX,T+DTU)
608. TTMIN=T
609. DTD=DTU/2.
610. GO TO 1091
611. 2281 X(1)=0.
612. MODE=0
613. IN=IN-1
614. IL=2
615. GO TO 2207
616. 224 IF(X(2)+1.0)2240,2249,2249
617. 2240 BS(2)=0.
618. A(2,2)=1.E25
619. GO TO 2207
620. 2249 CALL CRECT(MOE)
621. TMIN=TTMIN
622. TMAX=TTMAX
623. IF(KR(7)=1) 21,21,19
624. 11 PIEASE=SPEASE
625. RETURN
626. END

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B21A, THERM

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1. CB21A
2. SUBROUTINE THERM
3. DIMENSION CIJ( 60,1),TF(1)
4. EQUIVALENCE (TU(121),TF),(VNU,CIJ)
5. COMMON /BLQCOM/FAMDA( 60),FAMDB( 60),N ,FR( 60,15),W(3),LEF( 8)
6. 1 ,LEFS( 8),PIEASE,LEFW( 8),L2,L3
7. 3 COMMON/EQPCOM/RB(60,3),RC(60,3),RD(60,3),RE(60,3),RF(60,3),RG(60,3
8. 1),TU(60,3),FF(60),FFA,IFC(60),ATA(8),ATB(8),ATC(8),WAT(8),RA(60,3)
9. 5,
10. 2 KAT( 8),IR( 8),IS,KR(10),LAMI( 60),P,T,TK( 8, 8),VN( 60),
11. 3 VNU( 60, 8),ITFF,KR2,HCH,NCV,WM,WTH( 60),Y( 60),YV( 60),GG( 60)
12. 4 ,TQ( 8, 8),EPOVRK,SIGMA,BASHOL
13. COMMON /EQTCOM/SIP,HIP,EL,ENL,FLIQ,CPF,IRE,IER,AA,ITS,IN,IL,IT,
14. 1 MODE,HMELT,SMELT,TMAX,THIN,MELT,SUMN,SUML,WS,WSS,B1,ISP2,ISPG,
15. 2 ISP,KKJ,SVA,SVB,SVC,SVD,SUMC,FFF,CMF,EP,RV,IFCJC,WTG,WTL,JC,HG,
16. 3 CPG,TTMIN,TTMAX,L7,L8,IB( 9),EB( 8),EBL( 8),A(14,14), B(14),
17. 4 IP( 60),ALP( 8),FNU( 8),GAMH( 8),GAMF( 8),SLAM( 8),DY( 60),RVS,
18. 5 CP( 60), H( 60),SB( 60),TC( 60),VLNK( 60),E( 60),PNUS( 8),
19. 6 BC( 8),BLNK( 8),BY( 8),IBC( 8),BE( 8),JJ( 4)
20. COMMON/INTCOM/KKR(20),KIN,KOUT
21. 5 MODE=KR(1)
22. IF (ITS) 50,10,50
23. 10 WTG=0.
24. WTL=0.
25. IF (KR(8)) 40,40,15
26. 15 IF (IFC(N+1)=1) 25,20,25
27. 20 IF (T+.001-TF(N+1)) 25,25,30
28. 25 IFC(N+1)=1
29. VN(N+1)=0.
30. 30 DO 35 K=1,IS
31. 35 VNU(N+1,K)=-TQ(K,L3)
32. WTL=-VN(N+1)
33. 40 DUM2=0.
34. SUMN=0.
35. DO 45 I=1,IS
36. PNUS(I)=0.
37. 45 SLAM(I)=0.
38. 50 HMELT=0.
39. FLIQ=0.
40. SMELT=0.
41. MELT=1
42. THIN=TTMIN
43. TMAX=TTMAX
44. TFMAX=500.
45. VA= 1.9869
46. RT= VA*T
47. VB=ALOG(T)
48. I=1
49. DO 235 IK=1,N
50. JMELT=0
51. J=3
52. IF (IFC(I)+1) 165,85,85
53. 85 IF (IFC(I)) 90,95,120
54. 90 IF (MODE=1) 165,160,165
55. 95 IF (ITS) 165,100,165
56. 100 SUMN=SUMN+VN(I)
57. DUM1=WTH(I)+VN(I)
58. WTG=WTG+DUM1
59. DUM2=DUM2+DUM1/FF(I)
60. IF (VN(I).GT.1.E-29) Y(I)=ALOG(VN(I))
61. IF (IK=IS) 105,105,110

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62. 105 PNUS(I)=VN(I)
63. SLAM(I)=VN(I)/FF(I)
64. GO TO 165
65. 110 DO 115 K=1,IS
66. DUM1=VNU(I,K)*VN(I)
67. PNUS(K)=PNUS(K)+DUM1
68. 115 SLAM(K)=SLAM(K)+DUM1/FF(I)
69. GO TO 165
70. 120 IF (IFC(I)=1) 125,125,165
71. 125 IF (ITS) 150,130,150
72. 130 IF (KR(6)) 145,135,135
73. 135 IF (T-TF(I)+.001) 140,140,145
74. 140 IFC(I)=1
75. VN(I)=0.
76. GO TO 90
77. 145 WTL=WTL+VN(I)*WTM(I)
78. 150 IF (MODE=1) 165,155,165
79. 155 TMIN=AMAX1(TMIN,TF(I))
80. 160 TFMAX=AMAX1(TF(I),TFMAX)
81. 165 IF (T-ABS(TU(I,1))) 170,170,171
82. 170 J=1
83. GO TO 175
84. 171 IF (T-ABS(TU(I,2))) 172,172,175
85. 172 J=2
86. 175 CP(I)=VA*(RA(I,J)+T*(RB(I,J)+T*(RC(I,J)+T*(RD(I,J)+T*RE(I,J))))))
87. H(I)=VA*(RF(I,J)+T*(RA(I,J)+T*(RB(I,J)/2+T*(RC(I,J)/3+T*(RD(I,J)
88. 1/4+T*RE(I,J)/5))))))
89. SB(I)=VA*(RG(I,J)+RA(I,J)+VB+T*(RB(I,J)+T*(RC(I,J)/2+T*(RD(I,J)
90. 1/3+T*RE(I,J)/4))))))
91. IF (MODE=2) 210,180,180
92. 180 IF (IFC(I)=1) 210,185,210
93. 185 IF (TU(I,J)) 190,210,210
94. 190 IF (T+TU(I,J)) 200,195,205
95. 195 HMELT=H(I)-HMELT
96. SMELT=SB(I)-SMELT
97. MELT=I
98. IF (JMELT.EQ.1) GO TO 210
99. JMELT=1
100. J=J+1
101. GO TO 175
102. 200 TMAX=AMIN1(TMAX,-TU(I,J))
103. GO TO 210
104. 205 TMIN=AMAX1(TMIN,-TU(I,J))
105. 210 TC(I)=-H(I)/RT
106. VLNK(I)=TC(I)+SB(I)/1.9869
107. IF (IK=IS) 215,215,220
108. 215 BLNK(I)=VLNK(I)
109. IBC(I)=IFC(I)
110. BC(I)=TC(I)
111. GO TO 235
112. 220 DO 230 K=1,IS
113. IF (IBC(K)+1) 230,225,225
114. 225 VLNK(I)=VLNK(I)-VNU(I,K)*BLNK(K)
115. TC(I)=TC(I)-VNU(I,K)*BC(K)
116. 230 CONTINUE
117. 235 I=I+1
118. IF (MODE=1) 250,240,250
119. 240 IF (TFMAX-T) 245,250,250
120. 245 T=TFMAX
121. IF (T=500.) 248,248,5
122. 248 WRITE(KOUT,249)
123. STOP
124. 249 FORMAT(///38H NO AVAILABLE SURFACE SPECIES. . .STOP)
125. 250 IF (ITS) 385,255,385

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B21A, THERM

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126. 255 AA=P*WM
127. 365 SUMN=SUMN/P
128.      SUML=ALOG(SUMN)
129.      FFF=WTG/DUM2
130.      WTG=WTG/SUMN
131.      WTL=WTL/SUMN
132.      SUMC=1.0
133.      IF(KR(6)) 385,369,369
134.      369 00 370 I=1,IS
135.      PNUS(I)=PNUS(I)/SUMN
136. 370 SLAM(I)=SLAM(I)/SUMN*FFF
137. 375 IF (WTL/WTG=WS) 385,385,380
138. 380 SUMC=WTL/(WTG*WS)
139.      WTL=WTL/SUMC
140. 385 RETURN
141.      END

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B22A, MATER

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1. CB22A
2. SUBROUTINE MATER
3. DIMENSION VLAM(123,1),X(14)
4. EQUIVALENCE (AM(259),VLAM)
5. DIMENSION CIJ( 60,1),TF(1)
6. DIMENSION ECD(60)
7. EQUIVALENCE (TU(121),TF),(VNU,CIJ)
8. COMMON /BLQCOM/FAMOA( 60),FAMOB( 60),N      ,FR( 60,15),W(3),LEF( 8)
9. 1,LEFS( 8),PIEASE,LEFW( 8)
10. COMMON/BUMCOM/      BUMP,CORMA,EASE,ICORM,WDOOT,TFZ,I777,DTFMP,KIP,IX
11. COMMON/EQPCOM/RB(60,3),RC(60,3),RD(60,3),RE(60,3),RF(60,3),RG(60,3)
12. 1),TU(60,3),FF(60),FFA,IFC(60),ATA(8),ATB(8),ATC(8),WAT(8),RA(60,3)
13. 3,
14. 2 KAT( 8),IR( 8),IS,KR(10),LAMI( 60),P,T,TK( 8, 8),VN( 60),
15. 3 VNU( 60, 8),ITFF,KR2,HCH,NCV,WM,WTM( 60),Y( 60),YW( 60),GG( 60)
16. 4 ,TQ( 8, 8),EPOVRK,SIGMA,BASMOL
17. COMMON /EQTCOM/SIP,HIP,EL,ENL,FLIG,CPF,IRE,IER,AA,ITS,IN,IL,IT,
18. 1 MODE,HMELT,SMELT,TMAX,TMIN,MELT,SUMN,SUML,WS,WSS,B1,ISP2,ISPQ,
19. 2 ISP,KKJ,SVA,SVB,SVC,SVD,SUMC,FFF,CMF,EP,RV,IFCJC,WTG,WTI,JC,HG,
20. 3 CPG,TTMIN,TTMAX,L2,L3,IB( 9),EB( 8),EBL( 8),A(14,14),B(14),
21. 4 IP( 60),ALP( 8),PNU( 8),GAMH( 8),GAMF( 8),SLAM( 8),DY( 60),RVS,
22. 5 CP( 60),H( 60),SB( 60),TC( 60),VLNK( 60),E( 60),PNUS( 8),
23. 6 BC( 8),BLNK( 8),BY( 8),IBC( 8),BE( 8),JJ( 4)
24. COMMON/KINCOM/MT,FKF(10),EAK(10),EXK(10),PMU( 8,10),PMU( 8,10),
25. 1 DKPT(10),PKP(10),PKR(10),RAT(10),RSIG(10),MA(10),LL(10),PMR(10),
26. 2 PRMU( 8,10),EESE( 8)
27. COMMON/NONCOM/AM(123,123),DVNL(123),TCW,
28. 1VLNKW,DLPH( 7),OLPK( 6, 7),DTHW,DTKW( 6),FLUXJB( 7)
29. COMMON/INTCOM/KKR(20),KIN,KOUT
30. EQUIVALENCE(B,X)
31. WSS=WS
32. DO 5 I=1,IS
33. 5 IBC(I)=IFC(I)
34. IF(KR(6)) 40,20,20
35. 20 IF (ITS) 25,40,40
36. 25 DO 35 I=1,IS
37. IF (IBC(I)-1) 35,30,35
38. 30 IBC(I)=-1
39. 35 CONTINUE
40. RV=WSS-WTL/WTG
41. IF(ITS.EQ.0) RVS =RV
42. IF (KR(7)-1) 70,45,50
43. 45 IF (ITS) 70,60,70
44. 50 WRITE (KOUT,55) FFF,WTI,WTG,AA,RV,ALP,PNUS,SLAM
45. 55 FORMAT (32H FFF,WTI,WTG,AA,RV/ALP/PNUS/SLAM/1X5E12.5/(1X10E12.5))
46. KR(7)=KR(7)-1
47. IF (KR(7)-1) 70,60,70
48. 60 WRITE (KOUT,65) (I,I=1,IS)
49. 65 FORMAT (50HITS TEMP PRES*MWT EQUIL ER MASBAL ER SCALE 7(I3,
50. 17H MASBAL)/90X3(I3,7H MASBAL))
51. C INITIALIZE
52. 70 EL=0.
53. CPG=0.
54. EP=P
55. CPF=0.
56. JC=0
57. JCS=0
58. ISP=IS+1
59. ISPQ=IS+2
60. B(1)=0.
61. B(2)=0.

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B22A. MATER

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62.      A(1,1)=0.
63.      A(1,2)=0.
64.      A(2,1)=0.
65.      A(2,2)=0.
66.      C      -----INITIALIZE CONTRIBUTION OF MOST SIGNIFICANT SPECIES IN EACH M
67.      DO 75 I=1,IS
68.      EB(I)=0.
69.      75      E(I)=AA*ALP(I)
70.      ISP2=ISPG
71.      C      - - - MAIN BASE SPECIES LOOP
72.      DO 325 IK=1,IS
73.      I=2-IR(IK)
74.      IF (KAT(IK)=99) 85,80,85
75.      80      PNUS(I-2)=0.
76.      C      ZERO MATRIX
77.      85      DO 90 K=1,ISPG
78.      90      A(K,I)=0.
79.      IF (ITS) 110,95,110
80.      C      NORMALIZE ON PRESSURE ON FIRST PASS
81.      95      VN(I-2)=VN(I-2)/SUMN
82.      ECO(I-2)=(1.-EASE)*Y(I-2)
83.      EBL(I-2)=0.
84.      IF (IBC(I-2)) 110,100,105
85.      100      Y(I-2)=Y(I-2)-SUML
86.      GO TO 110
87.      105      VN(I-2)=VN(I-2)/SUMC
88.      C      INITIALIZE SOME MORE
89.      110      B(I)=0.
90.      A(I,1)=0.
91.      IP(I-2)=0.
92.      C      SET FLAG INDICATING SIGNIFICANCE OF SPECIES IN MASS
93.      C      BALANCE(S) AND INCREMENT COUNT ON SIGNIFICANT SPECIES
94.      IF (VN(I-2)-EBL(I-2)) 120,120,115
95.      115      IP(I-2)=1
96.      C      TREAT BASE SPECIES CONTAINING BUT NOT REPRESENTING NON-PRESENT
97.      C      ELEMENTS IN SAME MANNER AS NON-PRESENT CONDENSED SPECIES
98.      120      IF (IBC(I-2)+1) 325,125,125
99.      125      IF (IBC(I-2)) 180,215,130
100.     130      A(I,1)=1.
101.     VA=VN(I-2)
102.     IF (IABS(IBC(I-2)-3)-1) 135,280,140
103.     135      A(2,I)=1.0
104.     GO TO 280
105.     140      IF (EB(I-2)-ABS(VA)) 145,150,150
106.     145      EB(I-2)=ABS(VA)
107.     IB(I-2)=I-2
108.     150      E(I-2)=E(I-2)-VA
109.     IF (KR(6)) 155,160,160
110.     155      IF (MODE=1) 280,170,280
111.     160      DO 165 K=1,IS
112.     165      A(K+2,I)=WTM(I-2)*(PNUS(K)/WTG+GAMF(K))
113.     A(I,I)=A(I,I)+1.
114.     170      TMIN=AMAX1(TMIN,TF(I-2))
115.     IF (T-TF(I-2)+.001) 175,175,180
116.     175      A(I,I)=1.0E+10
117.     E(I-2)=VN(I-2)+1.001E+10
118.     MODE=0
119.     180      IF (MODE=1) 185,190,185
120.     185      IF (KR(8)) 280,280,190
121.     190      IF (TF(I-2)+.001-T) 325,195,195
122.     195      IF (JC) 205,205,200
123.     200      IF (Y(I-2)-BJC) 325,325,205
124.     205      BJC=Y(I-2)-ECO(I-2)
125.     JCS=JC

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B22A, MATER

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126.      TMAX=TF(I-2)
127.      JC=I-2
128.      IPCJC=IBC(I-2)
129.      IF (KR(8)) 210,210,280
130. 210    A(1,JCS+2)=0.
131.      A(1,I)=-1.0
132.      B(1)=BJC
133.      GO TO 325
134.  C      ----GAS PHASE
135. 215    VA=VN(I-2)
136.      CPG=CPG+VA*CP(I-2)
137.      A(1,I)=VA
138.      A(2,I)=VA
139.      EP=EP+VA
140.      IF (KAT(IK)=99) 220,275,220
141. 220    IF (KR(6)) 275,250,225
142. 225    DO 230 K=1,IS
143.      230  A(K+2,I)=(VLAM(I-2,K)+GAMH(K)*H(I-2))*VA
144.      A(1,I)=A(1,I)+VA*RV
145.      DUM2=WTM(I-2)/WTG*WTL/WTG*VA
146.      DO 245 K=1,IS
147.      IF (EBL(K).GT.ABS(A(K+2,I))) GO TO 240
148.      IP(I-2)=-1
149.      IF (EB(K)-ABS(A(K+2,I))) 235,240,240
150. 235    EB(K)=ABS(A(K+2,I))
151.      IB(K)=I-2
152. 240    E(K)=E(K)-A(K+2,I)
153. 245    A(K+2,I)=A(K+2,I)+DUM2*PNUS(K)
154.      GO TO 280
155. 250    DUM1=WTM(I-2)/WTG*VA
156.      DUM2=WTL/WTG*DUM1
157.      IF (KR(4)) 255,255,260
158. 255    DUM1=0.
159.      VA=(RV+1.)*VA
160.      GO TO 265
161. 260    DUM1=DUM1*(1.-FFF/FF(I-2))
162.      VA=(RV+FFF/FF(I-2))*VA
163. 265    DO 270 K=1,IS
164.      270  A(K+2,I)=DUM1*SLAM(K)+DUM2*PNUS(K)
165.      A(1,I)=A(1,I)+VA
166. 275    EB(I-2)=ABS(VA)
167.      IB(I-2)=I-2
168.      E(I-2)=E(I-2)-VA
169. 280    IF (MODE=2) 320,300,285
170. 285    IF (IBC(I-2)) 325,295,290
171. 290    HOS=SB(I-2)
172.      GO TO 305
173. 295    HOS=SB(I-2)-1.9869*Y(I-2)-1.9869
174.      GO TO 310
175. 300    HOS=H(I-2)
176.      IF (IBC(I-2)) 325,310,305
177. 305    A(1,I)=HOS
178.      GO TO 315
179. 310    A(1,I)=HOS*VN(I-2)
180. 315    A(1,2)=A(1,2)-HOS*VN(I-2)
181. 320    CPF=CPF+CP(I-2)*VN(I-2)
182. 325    CONTINUE
183.      DO 330 I=1,IS
184.      BE(I)=E(I)
185. 330    BY(I)=Y(I)
186.      IER=0
187.      IRE=0
188.      EER=0.
189.  C      - - - MAIN NON-BASE SPECIES LOOP

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190. 350 LIM=N+KR(8)
191. IF (LIM-ISP) 730,355,355
192. 355 J=ISP
193. DO 725 IK=ISP,LIM
194. IF (IK-N) 365,365,360
195. 360 E(J)=1,E=10
196. IF (IFC(J)) 410,725,445
197. 365 IF (IFC(J)+1) 725,370,370
198. 370 IF (ITS) 390,375,390
199. 375 VN(J)=VN(J)/SUMN
200. IF (IFC(J)) 390,385,380
201. 380 VN(J)=VN(J)/SUMC
202. GO TO 390
203. 385 Y(J)=Y(J)-SUML
204. 390 E(J)=VLNK(J)-Y(J)
205. DO 405 I=1,IS
206. IF (IBC(I)) 400,400,395
207. 395 FNU(I)=0.
208. GO TO 405
209. 400 FNU(I)=VNU(J,I)
210. E(J)=E(J)+FNU(I)*BY(I)
211. 405 CONTINUE
212. IF (KR(6)) 409,409,406
213. 406 IF (ITS) 408,407,408
214. 407 ECD(J)=(1.-EASE)*E(J)
215. 408 E(J)=E(J)-ECD(J)
216. 409 EAB=ABS(E(J))
217. IF (IFC(J)) 410,590,445
218. C CONDENSED SPECIES
219. 410 EAB=E(J)
220. IF (KR(6)) 425,415,415
221. 415 IF (T-TF(J)+.001) 420,425,425
222. 420 EAB=0.
223. IF (KR(8)) 535,535,545
224. 425 IF (E(J)-EER) 535,535,430
225. 430 EER=E(J)
226. IF (IER) 435,435,440
227. 435 ISPG=ISPG+1
228. IER=ISPG
229. 440 IE=IER
230. IRE=IK
231. GO TO 450
232. 445 ISPG=ISPG+1
233. IE=ISPG
234. 450 WTR=0.
235. IF (KR(6)) 460,455,455
236. 455 TMIN=AMAX1(TF(J),TMIN)
237. WTR=WTM(J)/WTG
238. 460 DO 465 I=1,ISPG
239. A(I,IE)=0.
240. 465 A(IE,I)=0.
241. DO 480 K=1,IS
242. DUM1=VNU(J,K)
243. IF (IBC(K)-1) 470,470,480
244. 470 VA=DUM1*VN(J)
245. A(K+2,IE)=DUM1-WTR*(PNUS(K)+GAMF(K)*WTG)
246. BE(K)=BE(K)-VA
247. IF (ABS(VA)-ER(K)) 480,480,475
248. 475 EB(K)=ABS(VA)
249. IB(K)=IK
250. 480 CONTINUE
251. K=IE-ISP2
252. IF (IK-N) 505,505,485
253. 485 JJ(K)=JC

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254.      B(IE)=Y(JC)
255.      IF (JC-IS) 495,495,490
256.      490      A(IE,1)=TC(JC)
257.      B(IE)=E(JC)
258.      495      EAB=B(IE)
259.      IF (IFCJC) 715,715,500
260.      500      EAB=ABS(EAB)
261.      GO TO 715
262.      505      JJ(K)=J
263.      JJ(K)=J
264.      A(IE,1)=TC(J)
265.      B(IE)=E(J)
266.      IF (T+.001-TF(J)) 515,510,510
267.      510      IF (KR(8)) 530,530,540
268.      515      IF (MODE=1) 520,525,520
269.      520      IF (KR(6)) 530,525,525
270.      525      A(IE,IE)=1.E+10
271.      B(IE)=-VN(J)*1.001E+10
272.      MODE=0
273.      530      IF (MODE=2) 535,575,580
274.      535      IF (MODE=1) 715,540,715
275.      540      IF (T-TF(J)-.001) 545,545,560
276.      545      IF (JC) 555,555,550
277.      550      IF (E(J)-BJC) 725,725,555
278.      555      BJC=E(J)
279.      JC=IK
280.      IFCJC=IFC(JC)
281.      TMAX=TF(J)
282.      IF (KR(8)) 565,565,560
283.      560      IF (MODE=2) 725,575,580
284.      565      B(1)=BJC
285.      DO 570 K=1,IS
286.      570      A(1,K+2)=-FNU(K)
287.      A(1,1)=TC(J)
288.      GO TO 725
289.      575      HOS=H(J)
290.      GO TO 585
291.      580      HOS=SB(J)
292.      585      A(1,IE)=HOS
293.      A(1,2)=A(1,2)-VN(J)*HOS
294.      CPF=CPF+CP(J)*VN(J)
295.      GO TO 715
296.      C      GAS PHASE SPECIES
297.      590      IP(J)=0
298.      IF (VN(J)) 595,715,595
299.      595      IQ=0
300.      CPG=CPG+VN(J)*CP(J)
301.      IF (KR(6)) 625,600,605
302.      600      FFJ=FFF/FF(J)
303.      605      DUM1=WTM(J)/WTG+VN(J)
304.      DUM2=DUM1/WTG*WTL
305.      IF (KR(6)) 610,610,625
306.      610      IF (KR(4)) 615,615,620
307.      615      DUM1=0.
308.      FFJ=1.0
309.      GO TO 625
310.      620      DUM1=DUM1*(1.-FFJ)
311.      625      DO 680 KI=1,IS
312.      I=2-IR(KI)
313.      VA=VNU(J,I-2)*VN(J)
314.      IF (KAT(KI)-99) 630,645,630
315.      630      IF (KR(6)) 645,640,635
316.      635      VA=VA*RV+VN(J)*(VLAM(J,I-2)+GAMH(I-2)*H(J))
317.      BE(I-2)=BE(I-2)-VA

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318.      ABSVA=ABS(VA)
319.      VA=VA+PNUS(I-2)*DUM2
320.      GO TO 650
321. 640    VB=VA*FFJ
322.      VA=RV*VA+VB
323.      BE(I-2)=BE(I-2)-VA
324.      ABSVA=ABS(VA)
325.      VA=VA+SLAM(I-2)*DUM1+DUM2*PNUS(I-2)
326.      GO TO 650
327. 645    BE(I-2)=BE(I-2)-VA
328.      ABSVA=ABS(VA)
329. 650    IF (ABSV-EBL(I-2)) 660,660,655
330. 655    IQ=1
331.      IF (ABSV-EB(I-2)) 670,670,665
332. 660    IF (ABS(VA)-EBL(I-2)) 680,680,670
333. 665    EB(I-2)=ABSV
334.      IB(I-2)=IK
335. 670    DO 675 K=3,ISP2
336. 675    A(I,K)=A(I,K)+VA*FNU(K-2)
337.      B(I)=B(I)-VA*E(J)
338.      A(1,1)=A(1,1)-VA*TC(J)
339.      A(2,1)=A(2,1)+VN(J)*FNU(I-2)
340. 680    CONTINUE
341.      IF (IQ) 715,715,685
342. 685    EP=EP-VN(J)
343.      IP(J)=-1
344.      B(2)=B(2)-VN(J)*E(J)
345.      A(2,1)=A(2,1)-VN(J)*TC(J)
346.      IF (MODE=2) 710,690,695
347. 690    HOS=H(J)+VN(J)
348.      GO TO 700
349. 695    HOS=VN(J)+(SB(J)-1.9869*Y(J)-1.9869)
350. 700    DO 705 I=3,ISP2
351. 705    A(1,I)=HOS*FNU(I-2)+A(1,I)
352.      A(1,2)=A(1,2)-HOS
353.      A(1,1)=A(1,1)-HOS*TC(J)
354.      B(1)=B(1)-HOS*E(J)
355. 710    CPF=CPF+VN(J)*CP(J)
356. 715    IF (EL-EAB) 720,725,725
357. 720    EL=EAB
358. 725    J=J+1
359. 730    CONTINUE
360.      ISP3=IS+3
361.      IF (MODE=2) 785,735,760
362. 735    CPA=CPF*T
363.      SHMLT=HMELT+VN(MELT)
364.      EHS=AA*HIP+A(1,2)
365.      IF (KKJ+1) 750,740,750
366. 740    DUM1=SVA/AA*T
367.      EHS=AA*SVC-DUM1+A(1,2)
368.      HIP=-A(1,2)/AA
369.      A(1,2)=-AA*SVC-DUM1
370.      CPA=(CPF+2.*DUM1/T)*T
371.      DUM2=SVB/AA*T
372.      P=P-EP
373.      EP=0.
374.      IF (ABS(EHS/AA)-10.) 745,745,750
375. 745    EP=-P+SVD-DUM2
376.      A(2,1)=A(2,1)+DUM2
377.      A(2,2)=-DUM2
378. 750    IF (KR(2)-MODE) 765,755,765
379. 755    A(1,2)=-AA*HIP
380.      GO TO 765
381. 760    CPA=CPF

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382.      SHMLT=SMELT*VN(MELT)
383.      EHS=AA*SIP+A(1,2)-1.9869*(P-EP)
384.      A(1,2)=-AA*SIP
385.      765      B(1)=B(1)+EHS
386.      A(1,1)=A(1,1)+CPA
387.      IF (SHMLT) 785,785,770
388.      770      IF (EHS) 785,785,775
389.      775      EHS=EHS-SHMLT
390.      B(1)=B(1)-SHMLT
391.      IF (EHS) 780,785,785
392.      780      FLIQ=1.+EHS/SHMLT
393.      MODE=0
394.      A(1,1)=1.E+10
395.      TMIN=500.
396.      TMAX=5000.
397.      785      ENL=ABS(EP)/P*100.
398.      DO 810 I=3,ISP2
399.      E(I-2)=BE(I-2)
400.      EBL(I-2)=EB(I-2)*1.E-7
401.      A(I,2)=-AA*ALP(I-2)
402.      IF (IFC(I-2)-1) 795,795,790
403.      790      NFM=NFM+1
404.      GO TO 810
405.      795      IF (KR(6)) 805,805,800
406.      800      A(I,1)=A(I,1)+GAMH(I-2)*T*CPG
407.      E(I-2)=E(I-2)+WTL*GAMF(I-2)
408.      805      ER=E(I-2)
409.      ABER=ABS(ER)/(EB(I-2)+1.E-20)
410.      ENL=AMAX1(ABER,ENL)
411.      B(I)=B(I)+ER
412.      810      CONTINUE
413.      IF (ISP2-ISPQ) 815,880,880
414.      815      IV=0
415.      JZ=0
416.      C      ADD CONDENSED NONBASE SPECIES TO ARRAY
417.      DO 840 IE=ISP3,ISPQ
418.      J=IE-ISP2
419.      J=JJ(J)
420.      IF (J-IS) 820,820,830
421.      820      DO 825 K=1,IS
422.      825      A(IE,K+2)=0.
423.      A(IE,J+2)=-1.0
424.      GO TO 840
425.      830      DO 835 K=1,IS
426.      835      A(IE,K+2)=-VNU(J,K)
427.      840      CONTINUE
428.      C      ELIMINATE TERMS CORRESPONDING TO PRESENT BASE CONDENSED
429.      DO 855 K=1,IS
430.      IF (IFC(K)) 855,855,845
431.      845      DO 850 IE=ISP3,ISPQ
432.      850      A(IE,K+2)=0.
433.      855      CONTINUE
434.      880      B(2)=EP+B(2)
435.      IF (KR(6)) 5979,5979,5976
436.      5976      ENL=ABS(EP)/P*100.
437.      IF (MT) 5973,5973,5974
438.      5974      CALL KINET
439.      5973      CONTINUE
440.      DO 5975 I=1,IS
441.      IF (EB(I)) 5986,5986,5985
442.      5985      EB(I)=AMAX1(EB(I),ABS(E(I)))
443.      IF (ITS) 5978,5977,5978
444.      5977      EESE(I)=E(I)*(1.-EASE)
445.      5978      E(I)=E(I)-EESE(I)

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446.      B(I+2)=B(I+2)-EESE(I)
447. 5986 EB(I)=ABS(EB(I))
448.      IF(IFC(I)-1) 5971,5971,5975
449. 5971 ENL=AMAX1(ENL,ABS(E(I)/(EB(I)+1.E-20)))
450. 5975 CONTINUE
451. 5979 CONTINUE
452.      IF(ITS) 884,920,884
453.      884 IF(MODE-1) 910,890,885
454.      885 IF(ITS.EQ.0) GO TO 920
455.      IF(ABS(EH3/A(1,1))-0.0001) 910,910,920
456. 890 IF (IFCJC) 895,900,905
457. 895 IF (JC-IRE) 900,905,900
458. 905 MODE=0
459.      TMIN=TTMIN
460.      TMAX=TTMAX
461. 900 IF (ABS(B(1))-1.E-4) 910,910,920
462. 910 IF (EL-1.E-4) 915,915,920
463. 915 IF (ENL-1.E-5) 935,935,920
464. 920 IN=ISPQ
465.      IL=1
466.      IF (MODE) 925,925,930
467. 925 IN=ISPQ-1
468.      IL=2
469.      X(1)=0.
470. 930 RETURN
471. 935 IT=ITS+1
472.      ITS=-1
473.      GO TO 930
474.      END

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B23A, CRECT

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1.  CR23A
2.  SUBROUTINE CRECT(MOE)
3.  INTEGER FAMOA,FAMOB
4.  COMMON/INTCOM/KKR(20),KIN,KOUT
5.  DIMENSION CIJ( 60,1),TF(1)
6.  EQUIVALENCE (TU(121),TF),(VNU,CIJ)
7.  DIMENSION X(14)
8.  DIMENSION CMFF( 60)
9.  COMMON /BLOCOM/FAMOA( 60),FAMOB( 60),N      ,FR( 60,15),W(3),LEF( 8)
10. 1,LEFS( 8),PIEASE,LEFW( 8)
11. COMMON/EQPCOM/RB(60,3),RC(60,3),RD(60,3),RE(60,3),RF(60,3),RG(60,3
12. 1),TU(60,3),FF(60),FFA,IFC(60),ATA(8),ATB(8),ATC(8),WAT(8),RA(60,3)
13. 5,
14. 2 KAT( 8),IR( 8),IS,KR(10),LAMI( 60),P,T,TK( 8, 8),VN( 60),
15. 3 VNU( 60, 8),ITFF,KR2,HCH,NCV,WM,WTM( 60),Y( 60),YW( 60),GG( 60)
16. 4 ,TQ( 8, 8),EPOVRK,SIGMA,RASMOL
17. COMMON /EQTCOM/SIP,HIP,EL,ENL,FLIQ,CPF,IRE,IER,AA,ITS,IN,IL,IT,
18. 1 MODE,HMELT,SMELT,TMAX,TMIN,MELT,SUMN,SUML,WS,WSS,B1,ISP2,ISPG,
19. 2 ISP,KKJ,SVA,SVB, SVC, SVD, SUMC, FFF, CMF, EP, RV, IFCJC, WTG, WTL, JC, HG,
20. 3 CPG,TTMIN,TTMAX,L2,L3,IB( 9),EB( 8),EBL( 8),A(14,14),B(14),
21. 4 IP( 60),ALP( 8),FNU( 8),GAMH( 8),GAMF( 8),SLAM( 8),DY( 60),RVS,
22. 5 CP( 60), H( 60),SB( 60),TC( 60),VLNK( 60),E( 60),PNUS( 8),
23. 6 BC( 8),BLNK( 8),BY( 8),IBC( 8),BE( 8),JJ( 4)
24. EQUIVALENCE(DYA,DY)
25. DIMENSION DY(1,1)
26. EQUIVALENCE(B,X)
27. CLIM=AMAX1(1.,W(2)+W(3))*0.2*WTG
28. DWTL=0.
29. DWTG=0.
30. DUMP=P*1.E-7
31. BUMP=P*1.E-4
32. BULP=ALOG(BUMP)
33. CMF=1.
34. 5 K=0
35. DO 20 J=2,IS
36. IF (IB(J)-IB(J-1)) 10,15,20
37. 10 JA=IB(J)
38. IB(J)=IB(J-1)
39. IB(J-1)=JA
40. K=1
41. GO TO 20
42. 15 IB(J)=1000
43. 20 CONTINUE
44. IF (K) 25,25,5
45. 25 IB(IS+1)=1000
46. M=IB(1)
47. M1=1
48. L=IS+2
49. I=0
50. LL=1
51. LIM=N+KR(8)
52. DO 280 IK=1,LIM
53. I=I+1
54. IF (IK-IS) 30,30,45
55. 30 SLAM(I)=0.
56. IBC(I)=IFC(I)
57. PNUS(I)=0.
58. IF (IFC(I)-1) 35,35,75
59. 35 DYI=X(I+2)
60. IF (IFC(I)+1) 275,40,40
61. 40 IF (IFC(I)) 205,95,230

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62. 45 IF (IFC(I)+1) 75,50,50
63. 50 IF (IFC(I)) 70,55,85
64. 55 VA=E(I)-TC(I)*X(I)
65. DO 65 J=1,IS
66. IF (IBC(J)) 60,60,65
67. 60 VA=VA+VNU(I,J)*X(J+2)
68. 65 CONTINUE
69. DYI=VA
70. GO TO 95
71. 70 IF (IK-IRE) 75,80,75
72. 75 DYI=0.
73. GO TO 275
74. 80 IFC(I)=1
75. DYI=X(IER)
76. GO TO 230
77. 85 L=L+1
78. IF (L-IER) 90,85,90
79. 90 DYI=X(L)
80. GO TO 230
81. 95 DWTG=DWTG+VN(I)*DYI*WTM(I)
82. IF (IP(I)) 100,195,100
83. 100 IF (IK-M) 105,145,105
84. 105 IF (VN(I)-DUMP) 110,140,140
85. 110 IF (MOE) 195,195,115
86. 115 IF (DYI) 120,275,125
87. 120 IF (VN(I)/BUMP-.9999995-CMF*DYI) 275,275,130
88. 125 IF (BUMP/VN(I)-1.-CMF*DYI) 135,275,275
89. 130 CMF=(VN(I)/BUMP-.9999995)/DYI
90. GO TO 275
91. 135 CMF=(BUMP/VN(I)-1.)/DYI
92. GO TO 275
93. 140 IF (MOE) 175,175,150
94. 145 M1=M1+1
95. M=IB(M1)
96. 150 IF (DYI) 155,275,160
97. 155 IF (DYI*CMF+.999) 165,275,275
98. 160 IF (DYI*CMF-9.) 275,275,170
99. 165 CMF=-.999/DYI
100. GO TO 275
101. 170 CMF=9./DYI
102. GO TO 275
103. 175 IF (DYI*CMF-2.303) 180,190,190
104. 180 IF (DYI*CMF+6.909) 185,275,275
105. 185 CMF=-6.909/DYI
106. GO TO 275
107. 190 CMF=2.303/DYI
108. GO TO 275
109. 195 IF (Y(I)-BULP+ABS(DYI)*CMF) 275,200,200
110. 200 CMF=-(Y(I)-BULP)/ABS(DYI)
111. GO TO 275
112. C NON=PRESENT BASE
113. 205 IF (KR(6)) 215,210,210
114. 210 IF (T-TF(I)+.001) 275,215,215
115. 215 IF (Y(I)+CMF*DYI-0.1) 275,220,220
116. 220 DUM1=(.1-Y(I))/DYI
117. IF (DUM1-.001) 275,275,225
118. 225 CMF=DUM1
119. GO TO 275
120. 230 DWTL=DWTL+DYI*WTM(I)
121. IF (DYI) 235,275,250
122. 235 IF (VN(I)) 250,250,240
123. 240 IF (VN(I)+DYI*CMF) 245,250,250
124. 245 CMF=-VN(I)/DYI+1.00001
125. 250 IF (KR(6)) 265,255,255

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126. 255 CLIP=ABS(CLIM/WTM(I))
127. IF (ABS(CMF*DYI)-CLIP) 275,275,260
128. CMF=CLIP/ABS(DYI)
129. GO TO 275
130. 265 IF (ABS(CMF*DYI)-P) 275,275,270
131. 270 CMF=P/ABS(DYI)
132. 275 CMFF(I)=CMF
133. 280 DY(IK)=DYI
134. IF (KR(6)) 290,285,285
135. 285 RVL=AMAX1(.1,RV/2.)
136. CMF=AMIN1(CMF,WTG/ABS(ABS(DWTL-DWTG/WTG*WTL)/RVL-DWTG))
137. 290 IF (KR(7)=1) 315,315,300
138. 295 FORMAT (1X2(8X2HVN9X1HY8X2HDY7X5H9SCALE7X1HE4X6HIFC 1P)/(1XA4,5E10.
139. 13,I3,I2,1X,A4,5E10.3,I3,I2))
140. 300 NQ=I
141. WRITE (KOUT,295) (FAMOA(J),VN(J),Y(J),OYA(J,LL),CMFF(J),F(J),IFC(J
142. 1),IP(J),J=1,NQ)
143. WRITE (KOUT,310) (EB(I),I=1,IS)
144. WRITE (KOUT,310) (X(I),I=1,ISPG)
145. WRITE (KOUT,305) (IB(I),I=1,IS)
146. 305 FORMAT (10I5)
147. 310 FORMAT (8E12.4)
148. 315 CONTINUE
149. IF (X(1)) 320,360,320
150. 320 X1=X(1)*CMF
151. ABX=ABS(X(1))
152. IF (ABS(X1)=.5) 330,330,325
153. 325 CMF=.5/ABX
154. X1=CMF*X(1)
155. 330 IF (X1) 340,360,335
156. 335 TM=TMAX
157. X1=AMIN1(.2,X1)
158. GO TO 345
159. 340 TM=TMIN
160. X1=AMAX1(=.2,X1)
161. 345 DTM=(TM-T)/(TM*X1)
162. IF (DTM=1.) 350,355,355
163. 350 CMF=DTM*CMF
164. T=TM
165. GO TO 360
166. 355 T=T/(1.-X1)
167. 360 AA=AA*EXP(CMF*X(2))
168. M1=1
169. M=IB(1)
170. WTL=0.
171. WTG=0.
172. DUM2=0.
173. I=1
174. LIM=KR(8)+N
175. DO 495 IK=1,LIM
176. DYI=CMF*DY(IK)
177. IF (DYI) 395,390,395
178. 390 IF (IFC(I)) 495,435,485
179. 395 IF (IFC(I)) 455,400,480
180. 400 IF (IP(I)) 405,430,405
181. 405 IF (M=IK) 410,415,410
182. 410 IF (MOE) 430,430,420
183. 415 M1=M1+1
184. M=IB(M1)
185. 420 VN(I)=VN(I)*(1.+DYI)
186. IF (VN(I)) 430,430,425
187. 425 Y(I)=ALOG(VN(I))
188. GO TO 435
189. 430 Y(I)=Y(I)+DYI

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190. VN(I)=EXP(Y(I))
191. 435 VA=WTM(I)*VN(I)
192. WTG=WTG+VA
193. DUM2=DUM2+VA/FF(I)
194. IF (IK-IS) 440,440,445
195. 440 PNUS(I)=VN(I)
196. SLAM(I)=VN(I)/FF(I)
197. GO TO 495
198. 445 DO 450 K=1,IS
199. VA=VNU(I,K)*VN(I)
200. PNUS(K)=PNUS(K)+VA
201. 450 SLAM(K)=SLAM(K)+VA/FF(I)
202. GO TO 495
203. C NON-PRESENT BASE CORRECTIONS AND TESTS
204. 455 Y(I)=Y(I)+DYI
205. IF (Y(I)) 495,460,460
206. 460 IF (IFC(I)+1) 495,465,465
207. 465 IF (KR(6)) 475,470,470
208. 470 IF (T-TF(I)+.001) 495,475,475
209. 475 Y(I)=0.
210. IFC(I)=+1
211. GO TO 495
212. 480 VN(I)=VN(I)+DYI
213. IF (VN(I)) 490,490,485
214. 485 WTL=WTG+VN(I)*WTM(I)
215. GO TO 495
216. 490 VN(I)=0.
217. IFC(I)=-1
218. 495 I=I+1
219. FFF=WTG/DUM2
220. DO 500 I=1,IS
221. 500 SLAM(I)=SLAM(I)*FFF
222. RETURN
223. END

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B24A, INPUT

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1.  CB24A
2.  SUBROUTINE INPUT(PP)
3.  INTEGER FAMOA,FAMOB,CHAR,BLANK
4.  INTEGER AMOA,AMOB,AMOC,ATA,ATB,ATC
5.  INTEGER Z1/1H0/,Z2/2H00/
6.  INTEGER BL/1H /,G/1HG/,LI/1HL/,S/1HS/,ELECT/1HE/
7.  COMMON/INTCOM/KKR(20),KIN,KOUT
8.  DIMENSION CIJ(60,1),TF(1),J1(4),A1(4),TJ(3),ISN(5)
9.  EQUIVALENCE(TU(121),TF),(VNU,CIJ),(ISN(1),AMOA),(ISN(2),AMOB),
10.  1(ISN(3),AMOC)
11.  COMMON/EQTCOM/UM(8,8),KPHA(2),IM(8),JAT(5),ALPT(5),C(A),
12.  1 TAU( 8, 8),IC( 8),LIM( 8, 8),FFIN(120),NFIA(120),NFIB(120),
13.  2 IFMET( 60),IGMET( 60),ZIGEPS(2),SORCE(8)
14.  COMMON /BLQCOM/FAMOA( 60),FAMOB( 60),N ,FR( 60,15),W(3),LEF( 8)
15.  1,LEFS( 8),PIEASE,LEFW( 8)
16.  COMMON/EQPCOM/RB(60,3),RC(60,3),RD(60,3),RE(60,3),RF(60,3),RG(60,3
17.  1),TU(60,3),FF(60),FFA,IFC(60),ATA(8),ATB(8),ATC(8),WAT(8),RA(60,3)
18.  S,
19.  2 KAT( 8),IR( 8),IS,KR(10),LAMI( 60),P,T,TK( 8, 8),VN( 60),
20.  3 VNU( 60, 8),ITFF,KR2,HCH,NCV,WM,WTM( 60),Y( 60),YK( 60),GG( 60)
21.  4 ,TQ( 8, 8),EPOVRK,SIGMA,BASMOL
22.  COMMON/KINCOM/MT,PKF(10),EAK(10),EXK(10),PMU( 8,10),RMU( 8,10),
23.  1 DKPT(10),PKP(10),PKR(10),RAT(10),RSIG(10),MA(10),LL(10),PMR(10),
24.  2 PRMU( 8,10),EES( 8)
25.  301 FORMAT (I3,F7.0,7F10.4)
26.  302 FORMAT(5E15.8,I5)
27.  3020 FORMAT(1X6E12.5,F10.4,F11.4,I2/1X6E12.5,F10.4,F11.4,I2)
28.  3021 FORMAT(2A4,E12.4,2A4,E12.4,2A4,E12.4,20X)
29.  303 FORMAT(1H /1H /1H )
30.  304 FORMAT(1X,A2,3A4,8F7.3)
31.  305 FORMAT(54H0RELATIVE ELEMENTAL COMPOSITIONS, ATOMIC WTS/UNIT MASS
32.  1/6X6HSYMBOL,3X7HELEMENT4X9HATOMIC WTSX8HEDGE GAS4X10HPYRO,GAS 15X
33.  2 6HCHAR 15X10HPYRO,GAS 25X6HCHAR 25X10HPYRO,GAS 35X6HCHAR 3/
34.  3(8XA2,3X3A4,F10.5,7F13.7))
35.  306 FORMAT(I5,3F10.5,I5)
36.  DATA CHAR,BLANK/4HCHAR,4H /
37.  P=PP
38.  KR(3)=2
39.  KR(2)=KKR(12)+1
40.  IF(KR(2).EQ.3.OR.KR(2).EQ.8) KR(3)=6
41.  IF(KR(2).EQ.7) GO TO 3751
42.  3062 MT=0
43.  FFA=0.489
44.  FITMOL=26.7
45.  FITGMW=24.3
46.  GGA = 0.454
47.  BASMOL=32.0
48.  SIGMA=3.467
49.  EPOVRK=106.7
50.  NFF=0
51.  VINT=P*1.E=6
52.  YINT=ALOG(VINT)
53.  RMMG=1.
54.  IF (KR(2)) 334,334,321
55.  C READ GROUP 11 DATA
56.  321 READ(KIN,301)IS,FPAR,DUB2,DUB3,DUB4,DUB5,DUB6
57.  DUB6=0.0
58.  DUB7=0.0
59.  IF (DUB2.GT.0.) FITMOL=DUB2
60.  IF (DUB3.GT.0.) BASMOL=DUB3
61.  IF (DUB4.GT.0.) SIGMA=DUB4

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62.         IF (DUB5.GT.0.) EPOVRK=DUB5
63.         IF (DUB6.GT.0.) GGA =DUB6
64.         IF (DUB7.GT.0.) FITGMW=DUB7
65.         IF(FFAR) 3213,3212,3211
66. 3213 FFA=0.
67.         GO TO 3212
68. 3211 FFA=FFAR
69. 3212 CONTINUE
70.         JAT(5)=0
71.         IX=3
72.         IF (IS=10) 311,311,399
73. C        ELEMENTAL DATA
74. 311 READ(KIN,304) (KAT(J), ATA(J), ATB(J), ATC(J), WAT(J), (TK(J,I),
75. 1 I=1,7),J=1,IS)
76.         DO 327 K=1,7
77.         VA=0.
78.         DO 322 J=1,IS
79.         IF(KAT(J).EQ.ELECT)GO TO 325
80.         IF(TK(J,K)) 324,322,325
81. 324 VA=VA-TK(J,K)
82.         TK(J,K)=-TK(J,K)/WAT(J)
83.         GO TO 322
84. 325 VA=VA+TK(J,K)*WAT(J)
85. 322 CONTINUE
86.         IF(VA) 326,327,326
87. 326 DO 323 J=1,IS
88. 323 TK(J,K)=TK(J,K)/VA
89. 327 CONTINUE
90.         WRITE(KOUT,305) (KAT(J), ATA(J), ATB(J), ATC(J), WAT(J), (TK(J,I),
91. 1 I=1,7),J=1,IS)
92.         IF(DUB8.GT.0.01) WRITE(KOUT,3081) DUB8
93. 3081 FORMAT(/3X,34HABLATION CAN OCCUR FOR TEMP. G.T. ,F10.4,6H DEG K)
94.         WRITE (KOUT,308)
95. 308 FORMAT(/3X61HTHERMODYNAMIC PROPERTY CURVE-FIT DATA (SEE MANUAL FO
96. 1R FORMAT)/)
97.         ISP=IS+1
98.         IF(KR(3)) 399,399,334
99. 334 TFMAX=0.
100.        AAA=0.
101.        N=0
102.        II=ISP
103.        J=1
104.        IC1=1
105.        NFF=0
106. 342 READ(KIN,306)NFFS,(TJ(I),I=1,3),ITEMP
107.        IF(NFFS.EQ.0) GO TO 344
108.        NFF=NFFS
109. C        READ DIFFUSION DATA, GROUP 12
110.        READ(KIN,3021)(NFIA(I),NFIB(I),FFIN(I),I=1,NFF)
111.        GO TO 342
112. C        READ THERMOCHEM. DATA
113. 344 READ(KIN,4001)(ISN(I),I=1,5),(JAT(K),ALPT(K),K=1,4),JP,SPL,SPU,IC1
114. 4001 FORMAT(3A4,6X,2A3.4(A2,F3.0),A1,2F10.3,14X,I1)
115.        IF(JAT(1).EQ.8L) GO TO 399
116.        IF(IC1.EQ.1)GO TO 4003
117. 4002 WRITE(KOUT,4202)(ISN(I),I=1,3)
118. 4202 FORMAT(' THERMOCHEMICAL DATA CARD OUT OF ORDER ',3A4)
119.        STOP
120. 4003 IF(KPHA(1).EQ.1.OR.JP.EQ. G)GO TO 4201
121.        DO 4103 I=1,4
122.        IF(JAT(I).NE.J1(I)) GO TO 4201
123.        IF(ALPT(I)-A1(I)) 4201,4103,4201
124. 4103 CONTINUE
125.        GO TO 4004

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126. 4201 DO 4102 I=1,4
127.    J1(I)=JAT(I)
128. 4102 A1(I)=ALPT(I)
129.    DO 345 K=1,IS
130.    345 C(K)=0.
131.    DO 349 I=1,4
132.    IF(JAT(I).EQ.BL ) GO TO 349
133.    IF(JAT(I).EQ.Z1.OR,JAT(I).EQ.Z2) GO TO 349
134.    346 DO 347 K=1,IS
135.    KT=K
136.    IF(JAT(I).EQ.KAT(K)) GO TO 348
137.    347 CONTINUE
138. C REJECT SPECIES DATA CARDS FOR NON PRESENT ELEMENT.
139.    READ(KIN,303)
140.    IF(ITEMP.EQ.1.AND,JP.EQ.G)READ(KIN,3031)
141. 3031 FORMAT(1H ,/1H )
142.    GO TO 344
143.    348 C(KT)=ALPT(I)
144.    349 CONTINUE
145.    WT=0.
146.    L=1
147.    LAMKK=0
148.    DO 388 I=1,IS
149.    IF(C(I)) 387,388,387
150.    387 LAMKK=LAMKK+L
151.    WT=WT+C(I) * WAT(I)
152.    388 L=L+L
153.    IF(J-IS) 360,360,369
154.    360 JM=J-1
155.    DO 3601 L=1,IS
156. 3601 CIJ(L,J)=C(L)
157.    LAMI(J) = LAMKK
158.    IF (JM) 320,320,313
159.    313 DO 314 L=1,JM
160.    IML=IM(L)
161.    UGH=C(IML)
162.    UM(L,J)=0.
163.    IF(UGH) 353,314,353
164.    353 DO 393 I=1,L
165.    393 UM(I,J)=UM(I,J)-UM(I,L)*UGH
166.    DO 394 I=IML,IS
167.    394 C(I)=C(I)-TAU(I,L)*UGH
168.    314 UM(J,L)=0.
169.    320 DO 316 I=1,IS
170.    IF(ABS (C(I))-.001)316,316,317
171.    316 TAU(I,J)=0.
172.    DO 396 I=1,JM
173.    396 VNU(II,I)=-UM(I,J)
174.    DO 397 I=J,IS
175.    397 VNU(II,I)=0.
176.    LAMI(II)=LAMKK
177.    GO TO 370
178.    317 IM(J)=I
179.    UM(J,J)=1.
180.    DO 398 L=1,J
181.    398 UM(L,J)=UM(L,J)/C(I)
182.    DO 328 L=1,IS
183.    328 TAU(L,J)=C(L)/C(I)
184.    YC=YINT
185.    KK=J
186.    J=J+1
187.    IR(1)=-1
188.    IF (IS.EQ.1) GO TO 414
189.    IF(J-IS) 372,372,329

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190.      329 DO 330 L=2,IS
191.          JM=ISP-L
192.          IMJ=IM(JM+1)
193.          DO 330 K=1,JM
194.              UGH=TAU(IMJ,K)
195.              DO 330 I=1,IS
196.                  330 UM(I,K)=UM(I,K)+UGH*UM(I,JM+1)
197.                  DO 333 I=1,IS
198.                      337 IMI=IM(I)
199.                      IF(IMI-I) 336,333,336
200.                  336 DO 338 K=1,IS
201.                      V=UM(K,IMI)
202.                      UM(K,IMI)=UM(K,I)
203.                  338 UM(K,I)=V
204.                      IM(I)=IM(IMI)
205.                      IM(IMI)=IMI
206.                      GO TO 337
207.                  333 CONTINUE
208. C-----ELEMENT == BASE GAS CORRESPONDENCE
209. C INITIALIZE ROW AND COLUMN SUMS
210.     IG=IS
211.     DO 401 I=1,IS
212.         IR(I)=-1
213.     401 IC(I)=-1
214. C EVALUATE INITIAL SUMS
215.     LAMD=1
216.     DO 402 I=1,IS
217.         DO 403 J=1,IS
218.             LIM(I,J)=MOD(LAMI(J),LAMD,2)
219.             IC(J) = IC(J) + LIM(I,J)
220.         403 IR(I)= IR(I) + LIM(I,J)
221.     402 LAMD=LAMD+LAMD
222. C CHECK FOR ZEROS
223.     426 IZ=0
224.     404 DO 412 I=1,IS
225.         IF(IC(I)-IZ) 408,405,408
226.     405 DO 406 J=1,IS
227.         IF(LIM(J,I)) 407,406,407
228.     406 CONTINUE
229.     407 IC(I)=-J
230.         IR(J)=-I
231.         DO 428 K=1,IS
232.             LIM(J,I)=0
233.             IF(LIM(J,K)) 425,427,425
234.         425 IC(K)=IC(K)-1
235.             LIM(J,K)=0
236.         427 IF(LIM(K,I)) 422,428,422
237.     422 LIM(K,I)=0
238.         IR(K)=IR(K)-1
239.     428 CONTINUE
240.         GO TO 413
241.     408 IF(IR(I)-IZ) 412,409,412
242.     409 DO 410 J=1,IS
243.         IF(LIM(I,J)) 411,410,411
244.     411 IC(J)=-I
245.         IR(I)=-J
246.         LIM(I,J)=0
247.         GO TO 4101
248.     410 CONTINUE
249.     4101 DO 430 K=1,IS
250.         IF(LIM(K,J)) 424,429,424
251.     424 IR(K)=IR(K)-1
252.         LIM(K,J)=0
253.     429 IF(LIM(I,K)) 423,430,423

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254. 423 LIM(I,K)=0
255.   IC(K)=IC(K)-1
256. 430 CONTINUE
257.   GO TO 413
258. 412 CONTINUE
259.   IZ=IZ+1
260.   GO TO 404
261. 413 IG=IG-1
262.   J=IS+1
263.   IF(IG) 414,414,426
264. 414 FAMOA(IS)=AMOA
265.   FAMOB(IS)=AMOB
266.   DO 416 I=1,IS
267.     K=-IR(I)
268.     IC(I)=FAMOA(K)
269.     416 IM(I)=FAMOB(K)
270. 417 FORMAT(///5X9HELEMENT ,18A4)
271. 418 FORMAT( 5X9HBASE SP 6(4X2A4))
272.   GO TO 372
273. 369 DO 361 L=1,IS
274.   VNU(II,L)=0.
275.   DO 361 I=1,IS
276. 361 VNU(II,L)=VNU(II,L)+C(I)*UM(L,I)
277.   LAMI(II)=LAMKK
278. 370 KK=II
279.   II=II+1
280.   YC= 0.
281. 372 K1=1
282.   K2=2
283. C TEST FOR PHASE, SET PHASE VARIABLE, SET TEMP. LIMITS
284.   IF(JP.NE. G ) GO TO 4005
285.   KPHA(1)=1
286.   KPHA(2)=1
287.   IF(ITEMP.EQ.0)GO TO 373
288.   K2=3
289.   K1=2
290.   K2=1
291.   TU(KK,1)=TJ(1)
292.   TU(KK,2)=TJ(2)
293.   TU(KK,3)=SPU
294.   GO TO 4006
295. 373 TU(KK,1)=TJ(2)
296.   TU(KK,2)=SPU
297.   GO TO 4006
298. 4005 IF(JP.NE. S) GO TO 4007
299.   KPHA(1)=2
300.   KPHA(2)=2
301.   GO TO 4008
302. 4007 KPHA(1)=3
303.   KPHA(2)=3
304. 4008 IF(SPU-TJ(2))4009,4010,4010
305. 4009 TU(KK,1)=SPU
306.   TU(KK,2)=TJ(2)
307.   GO TO 4006
308. 4010 TU(KK,1)=TJ(2)
309.   TU(KK,2)=SPU
310.   GO TO 4006
311. 4004 K2=3
312.   K1=2
313.   IF(JP.EQ. LI)KPHA(2)=3
314.   IF(JP.EQ. S)KPHA(2)=2
315.   IF(SPU-TJ(2))4012,4013,4013
316. 4012 TU(KK,1)=TU(KK,1)
317.   TU(KK,2)=SPU

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318.      GO TO 4011
319.      4013 IF (SPL-TJ(2)) 4014,4015,4015
320.      4014 TU(KK,1)=-TU(KK,1)
321.      TU(KK,2)=TJ(2)
322.      GO TO 4011
323.      4015 TU(KK,2)=-TU(KK,2)
324.      READ(KIN,3022) RA(KK,K2),RB(KK,K2),RC(KK,K2),RD(KK,K2),RE(KK,K2),
325.      IC2,RF(KK,K2),RG(KK,K2),IC3,IC4
326.      3022 FORMAT(5E15.8,I5,/,3E15.8,30X,I5,/,79X,I1)
327.      JP=G
328.      NEW=1
329.      IF (IC2.NE.2.OR.IC3.NE.3.OR.IC4.NE.4) GO TO 4002
330.      GO TO 4016
331.      4011 JP= G
332.      NEW=1
333.      4006 READ(KIN,302) RA(KK,K2),RB(KK,K2),RC(KK,K2),RD(KK,K2),RE(KK,K2),IC2
334.      IF (IC2.NE.2) GO TO 4002
335.      READ(KIN,302) RF(KK,K2),RG(KK,K2),RA(KK,K1),RB(KK,K1),RC(KK,K1),IC3
336.      IF (IC3.NE.3) GO TO 4002
337.      READ(KIN,302) RD(KK,K1),RE(KK,K1),RF(KK,K1),RG(KK,K1),RDUM,IC4
338.      IF (IC4.NE.4) GO TO 4002
339.      IF (ITEMP.EQ.0) GO TO 4016
340.      IF (KPHA(1).NE.1) GO TO 4016
341.      READ(KIN,302) RA(KK,KZ),RB(KK,KZ),RC(KK,KZ),RD(KK,KZ),RE(KK,KZ),IC5
342.      READ(KIN,302) RF(KK,KZ),RG(KK,KZ)
343.      IF (IC5.NE.5) GO TO 4002
344.      4016 CONTINUE
345.      C SET UP SPECIES FAIL TEMPERATURES TF(KK)
346.      IF (KPHA(2).NE.3) TF(KK)=8PU
347.      IF (NEW.NE.1) GO TO 3737
348.      GO TO 3721
349.      3737 IF (KPHA(1)=KPHA(2)) 3733,3736,3734
350.      3733 IF (KPHA(1)+KPHA(2)=5) 3734,3728,3734
351.      3734 WRITE(KOUT,3735) AMOA,AMOB
352.      3735 FORMAT(///25H BAD PHASE NUMBERING FOR 244)
353.      STOP
354.      3736 IF (KPHA(1)=1) 3734,3727,3728.
355.      3728 FF(KK) = 1.E+10
356.      GG(KK) = 1.E+10
357.      GO TO 3729
358.      3727 FF(KK)=(WT/FITMOL) **FFA
359.      IFMET(KK)=2
360.      GG(KK) = -1.
361.      3729 IF (NFF) 3726,3449,3730
362.      3730 DO 3723 I=1,NFF
363.      IF (NFIA(I)=AMOA) 3723,3724,3723
364.      3724 IF (NFIB(I)=AMOB) 3723,3720,3723
365.      3720 IF (FFIN(I)=100.) 3725,3731,3731
366.      3725 IF (FFIN(I)) 3480,3480,3481
367.      3480 GG(KK) = -FFIN(I)
368.      IFMET(KK)=1
369.      GO TO 3723
370.      3481 FF(KK) = FFIN(I)
371.      IFMET(KK)=1
372.      GO TO 3723
373.      3731 TF(KK)=FFIN(I)
374.      3723 CONTINUE
375.      IF (GG(KK)) 3449,3449,3455
376.      C ZIGEPS=0. CAN BE INPUT AND USED IN METHOD 3. ZIGEPS(1)=SIGMA(I)
377.      C ZIGEPS(2)=EPS(I),NO PRESENT METHOD FOR INPUT.
378.      3449 IF (ZIGEPS(1)=100.) 3453,3452,3452
379.      3453 IF (ZIGEPS(1)) 3452,3452,3441
380.      3441 IF (ZIGEPS(2)) 3452,3452,3443
381.      3443 GG(KK) = ZIGEPS(1)/SIGMA * (ZIGEPS(2)/EPOVRK)**.0795 *
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382.      1 (WT/BASMOI)**.25
383.      IGMET(KK)=3
384.      GO TO 3455
385.      3452 IF (KPHA(1)=1)3456,3457,3456
386.      3456 GG(KK) = 1.E+10
387.      GO TO 3455
388.      3457 GG(KK) = (WT/FITGMW)**GGA
389.      IGMET(KK)=2
390.      3455 CONTINUE
391.      3726 IF(KR(3)=6) 3722,3721,3722
392.      3A21 FORMAT(1X,3A4,5X,2A3,4(A2,F3,0),A1,2F10,3,14X,I1)
393.      3721 WRITE(KOUT,3821)(ISN(K),K=1,5),(JAT(K),ALPT(K),K=1,4),JP,SPL,SPU
394.      1,IC1
395.      WRITE(KOUT,3061) (TU(KK,K),RA(KK,K),RB(KK,K),RC(KK,K),RD(KK,K),
396.      1RE(KK,K),RF(KK,K),RG(KK,K), K=1,3)
397.      IF(NEW,NE,1)GO TO 3722
398.      NEW=0
399.      GO TO 344
400.      3061 FORMAT(F10,2,7E17,8)
401.      3722 FAMOA(KK)=AMOA
402.      FAMOB(KK)=AMOB
403.      WTM(KK)=WT
404.      N=N+1
405.      IF(KPHA(1)=1)3734,362,364
406.      364 IFC(KK)=1
407.      VN(KK)=0.
408.      Y(KK)=YC
409.      IF(TF(KK)=TFMAX)344,344,371
410.      371 TFMAX=TF(KK)
411.      GO TO 344
412.      362 IFC(KK)=0
413.      VN(KK)=VINT
414.      Y(KK)=YINT
415.      GO TO 344
416.      309 WRITE (KOUT,417) (ATA(I),ATB(I),ATC(I),I=1,IS)
417.      WRITE (KOUT,418) (IC(I),IM(I),I=1,IS)
418.      5001 WRITE(KOUT,110) SIGMA,EPOVRK,BASMOI
419.      110 FORMAT(//3X30HMOLECULAR TRANSPORT PROPERTIES/5X75HVISCOSECITY .....
420.      1 BUDDENBERG = WILKE MIXTURE FORMULA WITH MU(I) CALCULATED ON/21X34
421.      2HTHE BASIS OF D(I,I) = DBAR/G(I)**2//5X80HTHERMAL CONDUCTIVITY ...
422.      3.. MASON = SAXENA MIXTURE FORMULA WITH EUCKEN CORRECTION//5X73HDI
423.      4FUSION COEFFICIENTS ..... D(I,J) = DBAR/(F(I)*F(J)) WITH DBAR BASE
424.      5D ON/21X8HSIGMA = ,F8.4,11H, EPOVRK = ,F9.4,13H, AND MREF = ,F8.4)
425.      WRITE (KOUT,111) FITMOL,FFA,FITGMW,GGA
426.      111 FORMAT(//7X16HMETHODS EMPLOYED//8X63H0 CONDENSED PHASE, VALUES FOR
427.      1 F(I) AND G(I) SET EQUAL TO 1.E+10//8X42H1 VALUES FOR F(I) (OR G(I
428.      2)) INPUT DIRECTLY//8X71H2 VALUES FOR F(I) (OR G(I)) CALCULATED BY
429.      3 F(I) =(M(I)/FITMOL)**FFA AND/10X65HG(I) = (M(I)/FITGMW)**GGA WHER
430.      4E M(I) IS SPECIES MOLECULAR WEIGHT,/10X,9HFITMOL = ,F8.4,12H, AND
431.      5FFA = ,F6.4,11H, FITGMW = F8.4,12H, AND GGA = ,F6.4)
432.      WRITE(KOUT,112)
433.      112 FORMAT(//7X73HSPECIES F(I) METHOD G(I) METHOD SPECIES F(
434.      *I) METHOD G(I) METHOD)
435.      WRITE (KOUT,113)((FAMOA(KK),FAMOB(KK),FF(KK),IFMET(KK),GG(KK),IGME
436.      1T(KK)),KK=1,N)
437.      113 FORMAT(7X,2A4,1X,F5.3,3X,I1,3X,F5.3,3X,I1,10X,2A4,1X,F5.3,3X,I1,3X
438.      1,F5.3,3X,I1)
439.      WRITE (KOUT,419)
440.      419 FORMAT (//3X61HSTAGNATION SOLUTION FOLLOWED BY BOUNDARY-LAYER EDGE
441.      1 EXPANSION/)
442.      DO 375 L=1,7
443.      DO 375 I=1,IS
444.      TO(I,L)=0.
445.      DO 375 K=1,IS

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B24A, INPUT

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446.      375 TQ(I,L)=TQ(I,L)+UM(I,K)*TK(K,L)
447.      IF(KR(2)=5) 3752,3752,3751
448.      3751 CONTINUE
449.      240 FORMAT(8F10.6)
450.      245 FORMAT (2I3)
451.      250 FORMAT(3E10.4)
452. C      READ SURFACE KINETIC DATA, GROUP 14
453.      255 READ(KIN,245)MT
454.      IF(MT) 3752,3752,256
455.      256 DO 260 M=1,MT
456.          READ(KIN,250)FKF(M),EAK(M),EXK(M)
457.          READ(KIN,240)(RMU(I,M),I=1,IS)
458.          260 READ(KIN,240)(PMU(I,M),I=1,IS)
459.          265 FORMAT (/3X,7HKINETIC)
460.          270 FORMAT (3X,11HREACTION=,I7,9I10)
461.          275 FORMAT (/3X,8HREACTANT)
462.          280 FORMAT (5X,12HCOEFFICIENTS/)
463.          285 FORMAT (8X,2A4,F8.2,9F10.2)
464.          290 FORMAT (/3X,7HPRODUCT)
465.          295 FORMAT (/3X,12HPRE-EXPONENT)
466.          200 FORMAT (5X,6HFACTOR,4X,10E10.3)
467.          205 FORMAT (/3X,10HACTIVATION)
468.          210 FORMAT (5X,6HENERGY,4X,10E10.3)
469.          215 FORMAT (/3X,8HREACTION)
470.          220 FORMAT (5X,5HORDER,5X,10E10.3)
471.          WRITE(KOUT,265)
472.          WRITE(KOUT,270)(M,M=1,MT)
473.          WRITE(KOUT,275)
474.          WRITE(KOUT,280)
475.          DO 225 I=1,IS
476.              225 WRITE(KOUT,285)FAMOA(I),FAMOB(I),(RMU(I,M),M=1,MT)
477.              WRITE(KOUT,290)
478.              WRITE(KOUT,280)
479.              DO 230 I=1,IS
480.                  230 WRITE(KOUT,285)FAMOA(I),FAMOB(I),(PMU(I,M),M=1,MT)
481.                  WRITE(KOUT,295)
482.                  WRITE(KOUT,200)(FKF(M),M=1,MT)
483.                  WRITE(KOUT,205)
484.                  WRITE(KOUT,210)(EAK(M),M=1,MT)
485.                  WRITE(KOUT,215)
486.                  WRITE(KOUT,220)(EXK(M),M=1,MT)
487.      3752 VN(N+1)=0.
488.          IFC(N+1)=-1
489.          WTM(N+1)=-1.
490.          FAMOA(N+1)=CHAR
491.          FAMOB(N+1)=BLANK
492.          TF(N+1)=50000.
493. C      NEW JANNAF CHEMISTRY USES ELECTRON=E, BLIMP TESTS FOR ELECT=99
494.          DO 231 I=1,IS
495.              231 IF(KAT(I).EQ.1HE) KAT(I)=99
496.              IF(DUBB.GT.0.) TF(N+1) = DUBB
497.          RETURN
498.      END

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1.  CB25A
2.  SUBROUTINE PROPS
3.  INTEGER FAMDA,FAMOB
4.  COMMON/TEMCOM/ VK( 8),PA( 9, 9),PV( 9, 9)
5.  COMMON /BLQCOM/FAMDA( 60),FAMOB( 60),N      ,FR( 60,15),W(3),LEF( 8)
6.  1,LEF8( 8),PIEASE,LEFW( 8)
7.  COMMON/EDGCOM/      PE(40, 1),PTE(40, 1),SPE( 6,40, 1),DUES,
8.  1UE(40),RHOE(40),VMUE(40),TE(40),UEDGE,DUEDEGE,D2UEDG,VMWE,HE,C90
9.  2,DSIP(40),IDSIP,TTVC,TVCC(40),HEA(40),SF(20),CS(20),CSPR(20),
10.  3 CG(20),CGP(20),SREF,GEP,NEN
11.  COMMON/EQPCOM/RB(60,3),RC(60,3),RD(60,3),RE(60,3),RF(60,3),RG(60,3
12.  1),TU(60,3),FF(60),FFA,IFC(60),ATA(8),ATB(8),ATC(8),WAT(8),RA(60,3)
13.  3,
14.  2 KAT( 8),IR( 8),IS,KR(10),LAMI( 60),P,T,TK( 8, 8),VN( 60),
15.  3 VNU( 60, 8),ITFF,KR2,HCH,NCV,WM,WTM( 60),Y( 60),YW( 60),GG( 60)
16.  4 ,TQ( 8, 8),EPOVRK,SIGMA,BASMOL
17.  COMMON /EQTCOM/SIP,HIP,EL,ENL,FLIQ,CPF,IRE,IER,AA,ITS,IN,IL,IT,
18.  1 MODE,WMELT,SMELT,TMAX,TMIN,MELT,SUMN,SUML,WS,WSS,B1,ISP2,ISPG,
19.  2 ISP,KKJ,SVA,SVB,SV,SV,SMC,FFF,CMF,EP,RV,IFCJC,WTG,WTI,JC,HG,
20.  3 CPG,TTMIN,TTMAX,L2,L3,IB( 9),EB( 8),EBL( 8),A(14,14),B(14),
21.  4 IP( 60),ALP( 8),FNU( 8),GAMH( 8),GAMF( 8),SLAM( 8),DY( 60),RVS,
22.  5 CP( 60),H( 60),SB( 60),TC( 60),VLNK( 60),E( 60),PNUS( 8),
23.  6 BC( 8),BLNK( 8),BY( 8),IBC( 8),BE( 8),JJ( 4)
24.  COMMON /INTCOM/KKR(20),KIN,KOUT,MAT1I,MAT2I,MAT1J,MAT2J,NETA,II,
25.  1ISS,NS,ITT,NTIME,NSP,NSPM1,NAM,NLEQ,NNLEQ,NRNL,MITS,KAPPA,CBAR,
26.  2CASE(15),BB(8), MWE,NON,KD(10),ITEM,NITEM,KR17,NBT,NBT2,IDENT,
27.  3 KR9(40),KAUXO,JTIME,JSPEC,MD(3)
28.  COMMON /PRPCOM/PR(15),TT(15),RHO(15),SC(15),CAPC(15),QR(15),HH(15)
29.  1,CPBAR(15),VMW(15),PHIK(15, 6),DRHOH,DRHOK( 6),ZK( 6),DZKH( 6), 0
30.  2MU3K( 6),DMU4K( 6),DTK( 6),OPHIKH( 6),DPRK( 6),DSCK( 6),DCAPCK( 6)
31.  3,DHTILK( 6),DGRK( 6),DCPBK( 6),DCPTK( 6),DMU12K( 6),DZKK( 6, 6)
32.  4,DPHIKK( 6, 6), DMU4H,DMU3H,DHTILH,VMU12,CT,CTR,CPTIL,HTIL
33.  5,VMU3,OTH,DCAPCH,DPRH,DSCH,DGRH,DCPBH,DCPTH,DMU12H,VMU(15), RHOP
34.  6(15),PHIKP(15),HP,TP,ZKP( 6),VMU3P,VMU4P,HTILP,CRHO(14),GMR(15)
35.  COMMON/WALCOM/FW(40, 1),TW(40, 1),HW(40, 1),SPW( 6,40, 1)
36.  1,RHOVW(40, 1),FLUXJ( 3,40, -1),IHW,ITW,IFW,ISPW,IRHOVW,IFLUXJ
37.  DIMENSION PRP(1)
38.  EQUIVALENCE (PRP(1),PV(1))
39.  IF(II=1) 310,300,310
40.  300 IF(KKR(14)=10) 310,302,302
41.  302 KKR(14)=KKR(14)+10
42.  GO TO 300
43.  310 IF(T=100.01) 312,312,320
44.  312 KKR(14)=KKR(14)+10
45.  320 WM=AA/P
46.  ISV=IS
47.  IS=NSP
48.  ISVP=ISV+1
49.  543 ISV2=ISV+2
50.  CT=0.5
51.  ISM=IS-1
52.  ISP=IS+1
53.  ISP2=IS+2
54.  TT(II)=T+1.8
55.  RHO(II)=AA/(1.3146+T)
56.  CTR=CT+1.9876
57.  C FORM NECESSARY SUMMATIONS
58.  PMU2=0.
59.  CPTIL=0.
60.  WTG=0.
61.  HG=0.

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B25A, PROPS

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62. CPG=0.
63. HTIL=0.
64. PMU1=0.
65. TMU3=0.
66. I=1
67. DO 451 IK=1,N
68. IF(KAT(ISV)=99) 544,541,544
69. 541 IF(IK=ISV) 544,451,542
70. 542 H(I)=H(I)-VNU(I,ISV)*H(ISV)
71. WTM(I)=WTM(I)-VNU(I,ISV)*WTM(ISV)
72. CP(I)=CP(I)-VNU(I,ISV)*CP(ISV)
73. 544 IF(IFC(I)) 451,4550,451
74. 4550 PMU1=PMU1+VN(I)*FF(I)
75. 451 I=I+1
76. VMU1=PMU1/P
77. AMU5=0.
78. PMU6=0.
79. WDZ=1.385
80. WD4 = 0.284*WDZ
81. DO 454 I=1,N
82. VA=VN(I)/FF(I)
83. IF (I.GT.IS) GO TO 452
84. VK(I)=VN(I)
85. ZK(I)=VA
86. 452 IF(IFC(I).NE.0) GO TO 454
87. ASTAR = 1.13 * GG(I)/FF(I) * GG(I)/FF(I)
88. WD2=1.2*ASTAR/PMU1
89. WD7=WDZ/PMU1-WD2
90. WD5=.32*ASTAR/PMU1
91. WD8=WD4/PMU1-WD5
92. VB=VA*WTM(I)
93. VC=VN(I)*FF(I)
94. IF(I.LE.IS) GO TO 457
95. IF (I.GT.ISV) GO TO 456
96. IF (KAT(I).NE.99) GO TO 457
97. WTM(I)=0.
98. CP(I)=0.
99. H(I)=0.
100. GO TO 454
101. 456 DO 453 K=1,ISM
102. VK(K)=VK(K)+VN(I)*VNU(I,K)
103. 453 ZK(K)=ZK(K)+VA*VNU(I,K)
104. 457 PMU2=PMU2+VB
105. TMU3=TMU3+VA
106. CPTIL=VA*CP(I)+CPTIL
107. HTIL=HTIL+VA*H(I)
108. WTG=WTG+VN(I)*WTM(I)
109. HG=HG+VN(I)*H(I)
110. CPG=CPG+VN(I)*CP(I)
111. AMU5=AMU5+VB/(WDZ-VC+WD7)
112. PMU6=PMU6+VA/(WD4-VC+WD8)
113. 454 CONTINUE
114. VMU5=AMU5/WTG
115. VMU6=(PMU6 +CPTIL/1.9869-2.5*TMU3)/P
116. VMU2=PMU2/P
117. VMU3=TMU3/PMU2
118. CPTIL = CPTIL / PMU2
119. HTIL = HTIL / PMU2 * 1.8
120. HG=HG/WTG
121. CPG=CPG/WTG
122. WM=WTG/P
123. ZKS = 1.0
124. VKS=1.0
125. DO 95 K=1,ISM

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B25A, PROPS

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126.      VK(K)=VK(K)/WTG*WTM(K)
127.      95 ZK(K) = ZK(K) / PMU2 * WTM(K)
128.      OMEGA=1.07/(T/EPOVRK) **0.159
129.      DBAR = 2.82861E-6/(SIGMA * SIGMA) * T/P*SQRT(T/BASHQL)/OMEGA
130.      VMU(II)=RHO(II)*DBAR *VMU5/VMU1
131.      IF(KKR(5)) 461,461,460
132.      460 RHOE(ISS)=RHO(II)
133.      VMUE(ISS)=VMU (II)
134.      VMHE=WM
135.      IS=ISV
136.      RETURN
137.      461 CONTINUE
138.      CAPC(II)=RHO(II)/RHOE(ISS)*VMU(II)/VMUE(ISS)
139.      VMW(II)=WM
140.      VLAM=RHO(II)*DBAR/WM*VMU6/VMU1*1.9869
141.      SC(II)=VMU5/VMU2*WM
142.      IF (KKR(14)-1) 4613,4612,4611
143.      4611 FFK2=WM/VMU2
144.      VMU1=FFK2
145.      VMU3=1./WM
146.      CPTIL=CPG
147.      HTIL=HG*1.8
148.      DO 4614 K=1,ISM
149.      4614 ZK(K)=VK(K)
150.      4612 CT=0.
151.      CTR=0.
152.      4613 VMU12=VMU1*VMU2
153.      IF(KKR(20)) 9004,9005,9004
154.      9004 WRITE(KOUT,9006)OMEGA,DBAR,      VLAM,SC(II),PR(II),VMU1,VMU2,VMU3,T
155.      1T(II),VMU5,VMU6,FF(1),FF(2),FF(3),CPTIL,HTIL,(VK (I),WTM(I),ZK(I),
156.      2I=1,ISM),VMU(II)
157.      9005 CONTINUE
158.      IF(KR(6)) 5000,5340,5340
159.      5000 CPBAR(II)=CPG
160.      PR(II)=CPG/VMU6*VMU5/1.9869*WM
161.      NPR=ISP2
162.      DO 501 I=1,NPR
163.      DO 501 J=1,ISV2
164.      501 PA(I,J)=0.
165.      PA(3,1)=PMU2*CPTIL*T
166.      DO 502 K=3,ISV2
167.      IF (KKR(14)-1) 5016,5016,5017
168.      5016 FFK2=FF(K-2)
169.      5017 IF(IFC(K-2)) 502,5011,5014
170.      5011 PA(1,K)=VN(K-2)/FFK2
171.      GO TO 5013
172.      5014 PA(1,K)=1./FFK2
173.      5013 PA(2,K)=PA(1,K)*WTM(K-2)
174.      PA(3,K)=PA(1,K)*H(K-2)
175.      IF(K=ISP)5018,5018,5019
176.      5018 PA(K+1,K)=PA(1,K)
177.      5019 CONTINUE
178.      502 CONTINUE
179.      J=ISVP
180.      IF(ISVP,GT,N) GO TO 5070
181.      DO 507 IJ=ISVP,N
182.      IF(IFC(J)) 507,5021,507
183.      5021 PRP(1)=VN(J)/FFK2
184.      IF (KKR(14)-1) 5022,5022,5023
185.      5022 PRP(1)=VN(J)/FF(J)
186.      5023 PRP(2)=PRP(1)*WTM(J)
187.      PRP(3)=PRP(1)*H(J)
188.      DO 5024 I=4,ISP2
189.      5024 PRP(I)=PRP(1)*VNU(J,I-3)

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190.      DO 505 I=1,NPR
191.        PA(I,1)=PA(I,1)-TC(J)*PRP(I)
192.      DO 505 K=1,ISV
193.        IF(IFC(K)) 506,506,505
194.      506 PA(I,K+2)=PA(I,K+2)+PRP(I)*VNU(J,K)
195.      505 CONTINUE
196.      507 J=J+1
197.    5070 VA=AA/WTM(IS)
198.      DO 511 I=1,ISV2
199.        A(I,1)=A(I,1)*AA/1.8
200.      511 A(I,ISP2)=A(I,ISP2)*VA
201.      DO 512 J=3,ISP
202.        VA=AA/WTM(J-2)
203.      DO 512 I=1,ISV2
204.      512 A(I,J)=A(I,J)*VA-A(I,ISP2)
205.  C      FORM PA,A PRODUCT AND TRANSPOSE (TO ESTABLISH EQUIVALENCE
206.      DO 521 I=1,NPR
207.        DO 521 J=1,ISP
208.          PV(J,I)=PA(I,1)*A(I,J)
209.        DO 521 L=3,ISV2
210.      521 PV(J,I)=PV(J,I)+PA(I,L)*A(L,J)
211.        DO 533 K=1,ISM
212.          PV(K,1)=(PV(K,1)-VMU3*PV(K,2))/PMU2
213.          PV(K,3)=(PV(K,3)+1.8*HTIL*PV(K,2))/PMU2
214.        DO 531 J=1,ISM
215.      531 PV(K,J+3)=(PV(K,J+3)+WTM(J)-ZK(J)*PV(K,2))/PMU2
216.      533 PV(K,2)=CT*A(1,K)+PV(K,2)/PMU2
217.        PV(2,2)=PV(2,2)-1./P
218.  C      POOR MAN=8 EQUIVALENCE
219.        QR(II)=0.
220.        DCAPCH=CAPC(II)*(2.*A(2,1)-0.341*A(1,1))
221.        DPRH=0.
222.        DSCH=0.
223.        DQRH=0.
224.        DCPBH=0.
225.        DCPTH=0.
226.        DMU12H=0.
227.        DRHCH=RHQ(II)*(A(2,1)-A(1,1))
228.        DTH=T*A(1,1)*1.8
229.        DMU3H=PV(1,1)
230.        DMU4H=PV(1,2)
231.        DHTILH=PV(1,3)
232.        IF (NSPM1)5340,5340,5320
233.    5320 DO 534 K=1,ISM
234.          PHIK(II,K)=0.
235.          DPHIKH(K)=0.
236.          ORHOK(K)=RHQ(II)*(A(2,K+2)-A(1,K+2))
237.          DPRK(K)=0.
238.          DSKK(K)=0.
239.          DTK(K)=T*A(1,K+2)*1.8
240.          DCAPCK(K)=CAPC(II)*(2.*A(2,K+2)-0.341*A(1,K+2))
241.          DQRK(K)=0.
242.          DCPBK(K)=0.
243.          DCPTK(K)=0.
244.          DMU12K(K)=0.
245.          DMU3K(K)=PV(K+2,1)
246.          DMU4K(K)=PV(K+2,2)
247.          DHTILK(K)=PV(K+2,3)
248.          DZKH(K)=PV(1,K+3)
249.        DO 532 I=1,ISM
250.          DPHIKK(I,K)=0.
251.      532 DZKK(I,K)=PV(K+2,I+3)
252.      534 CONTINUE
253.    5340 LIM=N+KR(8)

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B25A, PROPS

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254.      DO 535 I=1,LIM
255.      IF(KR(6)) 5343,5344,5344
256.      5343 IF(MOD(IFC(I),3)) 535,5344,535
257.      5344 FR(I,II)=VN(I)/P
258.      IF(VN(I)) 5341,5341,535
259.      5341 IF(IFC(I)) 535,5342,535
260.      5342 FR(I,II)=1.E-30
261.      535 CONTINUE
262.      IF(KR(6)) 538,538,5350
263.      5350 IF (KR(1)-1) 536,5361,5360
264.      5361 Y(JC)=0.
265.      536 HW(ISS,ITT)=HG*1.8
266.      5360 DO 537 K=2,IS
267.      537 SPW(K-1,ISS,ITT)=VK(K-1)
268.      RHOVN(ISS,ITT)=-RV
269.      538 CONTINUE
270.      IF(KKR(20)) 9001,9002,9001
271.      9001 WRITE(KOUT,9006)DMU3H,DMU3K,DMU4H,DMU4K,DHTILH,DHTILK,DTW,DTK,DRHO
272.      1H,DRHOK,DZKH,DZKK,HG,VK
273.      9002 CONTINUE
274.      IS=ISV
275.      9006 FORMAT(/(1X1P10E12.5))
276.      ISP=ISVP
277.      ISP2=IS+2
278.      IF(II-1) 551,539,551
279.      539 DO 540 I=1,IS
280.      540 YW(I)=Y(I)
281.      551 RETURN
282.      END

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B26A, TAYLOR

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1.      CB26A
2.      SUBROUTINE TAYLOR (D,FM,F,P)
3.      DIMENSION FM(1),F(1),P(1)
4.      COMMON/INTCOM/ KR(20),KIN,KOUT,MAT1I,MAT2I,MAT1J,MAT2J,NETA,I
5.      D2=D*D
6.      IF(KR(10)-1) 1,2,4
7.      2 IF(I=NETA) 4,1,4
8.      4 FD=0.
9.      P(1)=(((FM(3)/6.,-FD/24.)*D-F(2)/2.)*D+F(1))*D
10.     P(2)=(((FD/30.,-FM(3)/8.)*D+F(2)/3.)*D-F(1)/2.)*D2
11.     P(3)=0.
12.     P(4)=(((FM(3)/20.,-FD/72.)*D-F(2)/8.)*D+F(1)/6.)*D2+D-P(3)
13.     GO TO 3
14.     1 FD=F(3)-FM(3)
15.     P(1)=(((F(3)/6.,-FD/24.)*D-F(2)/2.)*D+F(1))*D
16.     P(2)=(((FD/30.,-F(3)/8.)*D+F(2)/3.)*D-F(1)/2.)*D2
17.     P(4)=(((FD/252.,-F(3)/72.)*D+F(2)/30.)*D-F(1)/24.)*D2+D
18.     P(3)=(((F(3)/20.,-FD/72.)*D-F(2)/8.)*D+F(1)/6.)*D2+D-P(4)
19.     3 CONTINUE
20.     RETURN
21.     END

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1.  CB27A
2.  SUBROUTINE LINMAT
3.  COMMON/ETACOM/ETA(15),DETA(15),DSQ(14),DCU(14),B1(14),B2(14)
4.  1,LAR(123),BA1(43,18),BA2(30,15)
5.  COMMON/INTCOM/ KR(20),KIN,KOUT,MAT1I,MAT2I,MAT1J,MAT2J,NETA,I,IS,N
6.  19,IT,NTIME,NSP,NSPH1,NAM,NLEG,NNLEG,NRNL, ITS,KAPPA,CBAR,CASE(15)
7.  2,B(8), MWE,NON,KQ(10),ITEM,NITEM,KR17,NBT,NBT2,IDENT,KR9(40)
8.  3,KAUXD,JTIME,JSPEC,MD(3)
9.  DO 104 I=2,NETA
10.  DETA(I-1)=ETA(I)-ETA(I-1)
11.  DSQ(I-1)=DETA(I-1)*DETA(I-1)
12.  B1(I-1)=B(3)*DSQ(I-1)
13.  B2(I-1)=2.*B1(I-1)
14.  104 DCU(I-1)=DETA(I-1)*DSQ(I-1)
15.  MAT1I=3*NETA-2
16.  MAT2I=2 * NETA
17.  MAT1J= NETA+3
18.  MAT2J= NETA
19.  DO 108 I=1,MAT2I
20.  DO 108 J=1,MAT2J
21.  108 BA2(I,J)=0.
22.  DO 105 I=1,MAT1I
23.  DO 105 J=1,MAT1J
24.  105 BA1(I,J)=0.
25.  BA1(1,2)=1.
26.  BA1(1,3)= DSQ(1)/2.
27.  BA1(NETA,3) = DETA(1)
28.  BA1(MAT2I-1,3)=1.
29.  BA2(2,1)=DETA(1)
30.  BA2(NETA+1,1)=1.
31.  J=NETA
32.  DO 106 I=2,NETA
33.  BA1(I-1,I+2)=DETA(I-1)
34.  BA1(J,I+2)=1.
35.  BA1(J,I+3)=-1.
36.  BA2(I,1)=1.
37.  IF(I=NETA) 103,106,106
38.  103 BA2(I,I+1)=-1.
39.  106 J=J+1
40.  9060 FORMAT(2X1P12E10,3)
41.  9064 FORMAT(2X37HLINEAR MATRIX FOR MOMENTUM EQUATIONS,13,2H X13,
42.  127H, BEFORE AND AFTER SOLUTION)
43.  9079 FORMAT(2X44HLINEAR MATRIX FOR MASS AND ENERGY EQUATIONS,13,2H X13,
44.  127H, BEFORE AND AFTER SOLUTION)
45.  IF(KR(15)=1) 9062,9062,9061
46.  9061 WRITE(KOUT,9064) MAT1I,MAT1J
47.  DO 9063 I=1,MAT1I
48.  9063 WRITE(KOUT,9060)(BA1(I,J),J=1,MAT1J)
49.  9062 DO 107 LI=2,MAT1J
50.  107 CALL MATS1(BA1(1,LI))
51.  IF(KR(15)=1) 9069,9069,9066
52.  9066 DO 9067 I=1,MAT1I
53.  9067 WRITE(KOUT,9060)(BA1(I,J),J=1,MAT1J)
54.  WRITE(KOUT,9079) MAT2I,MAT2J
55.  DO 9068 I=1,MAT2I
56.  9068 WRITE(KOUT,9060)(BA2(I,J),J=1,MAT2J)
57.  9069 DO 110 LI=1,MAT2J
58.  110 CALL MATS2(BA2(1,LI))
59.  IF(KR(15)=1) 9072,9072,9071
60.  9071 DO 9073 I=1,MAT2I
61.  9073 WRITE(KOUT,9060)(BA2(I,J),J=1,MAT2J)

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B27A, LINMAT

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62. 9072 NLEQ=MAT1I+NSP*MAT2I
63.    NNLEQ=MAT1J+NSP*MAT2J
64.    NAM=NNLEQ-(N8PM1+2)
65.    NRNL=NSP+1
66.    LAR(NAM+1)=2
67.    J=2+MAT1J
68.    LL=NAM+2
69.    DO 111 L=LL,NNLEQ
70.      LAR(L)=J
71.      111 J=J+MAT2J
72.      L=NAM+1
73.      J=0
74.      DO 113 I=1,NAM
75.        J=J+1
76.        IF(LAR(L)-J) 113,112,113
77.        112 L=L+1
78.        J=J+1
79.        113 LAR(I)=J
80.        IF(KR(15)) 9901,9902,9901
81. 9901 CONTINUE
82. 9999 FORMAT(2X16HDEBUG LAR INDICE/(8X20I4))
83.    WRITE(KOUT,9999) LAR
84. 9902 CONTINUE
85.    RETURN
86.    END

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B28A, KINET

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1.  CB28A
2.  SUBROUTINE KINET
3.  COMMON /HISCOM/ C1,C2,C3
4.  COMMON /BUMCOM/ BUMP,CORMA,EASE
5.  COMMON /INTCOM/ KKR(20),KIN,KOUT
6.  DIMENSION ELKM(10),DELK(10)
7.  COMMON/EQPCOM/RB(60,3),RC(60,3),RD(60,3),RE(60,3),RF(60,3),RG(60,3)
8.  1),TU(60,3),FF(60),FFA,IFC(60),ATA(8),ATB(8),ATC(8),WAT(8),RA(60,3)
9.  3,
10.  2 KAT( 8),IR( 8),IS,KR(10),LAMI( 60),P,T,TK( 8, 8),VN( 60),
11.  3 VNU( 60, 8),ITFF,KR2,HCH,NCV,WM,WTM( 60),Y( 60),YW( 60),GG( 60)
12.  4 ,TG( 8, 8),EPOVRK,SIGMA,BASMO
13.  COMMON /EQTCOM/SIP,HIP,EL,ENL,FLIQ,CPF,IRE,IER,AA,ITS,IN,IL,IT,
14.  1 MODE,HMELT,SMELT,TMAX,TMIN,MELT,SUMN,SUML,WS,WSS,B1,ISP2,ISPO,
15.  2 ISP,KKJ,SYA,SVB,SVI,SVD,SUMC,FFF,CMF,EP,RV,IFCJC,WTG,WTI,JC,HG,
16.  3 CPG,TMIN,TMAX,L2,L3,IB( 9),EB( 8),EBL( 8),A(14,14),B(14),
17.  4 IP( 60),ALP( 8),FNU( 8),GAMH( 8),GAMF( 8),SLAM( 8),DY( 60),RVS,
18.  5 CP( 60),H( 60),SB( 60),TC( 60),VLNK( 60),E( 60),PMUS( 8),
19.  6 BC( 8),BLNK( 8),BY( 8),IBC( 8),BE( 8),JJ( 4)
20.  COMMON/KINCOM/MT,FKF(10),EAK(10),EXK(10),PMU( 8,10),RMU( 8,10),
21.  1 DKPT(10),PKP(10),PKR(10),RAT(10),RSIG(10),MA(10),LL(10),PMR(10),
22.  2 PRMU( 8,10),EASE( 8)
23.  5 FORMAT(13I3)
24.  10 RT = 1.9869 * T
25.  DO 40 M=1,MT
26.  SUMD = 0.
27.  SUMK = 0.
28.  SUMR = 0.
29.  SUMP = 0.
30.  DO 15 I=1,IS
31.  PRMU(I,M) = PMU(I,M) - RMU(I,M)
32.  SUMK = SUMK + PRMU(I,M) * VLNK(I)
33.  SUMR = SUMR + RMU(I,M) * Y(I)
34.  SUMP = SUMP + PMU(I,M) * Y(I)
35.  15 SUMD = SUMD + PRMU(I,M) * H(I)
36.  C EQUILIBRIUM CONSTANTS FOR KINETIC REACTIONS IN TERMS OF BASE SPECI
37.  C LOG KP=S
38.  C DERIVATIVES OF LOGS OF ABOVE KP=S WITH RESPECT TO LOG T
39.  DKPT(M) = SUMD / RT
40.  C RIGHT HAND SIDE (OR REVERSE PART) OF DRIVING POTENTIAL
41.  IF(ITS ) 19,14,16
42.  14 DELK(M)=0.
43.  16 IF(DELK(M)) 17,19,18
44.  17 SUMP=SUMP-DELK(M)
45.  GO TO 19
46.  18 SUMR=SUMR+DELK(M)
47.  19 ELKM(M)=SUMP-SUMK-SUMR
48.  PKP(M) = EXP(SUMP - SUMK)
49.  C LEFT HAND SIDE (OR FORWARD PART) OF DRIVING POTENTIAL
50.  PKR(M) = EXP(SUMR)
51.  VK1 = PKR(M) - PKP(M)
52.  IF (VK1) 25,20,25
53.  20 VK1 = 1.E - 9 * PKR(M)
54.  25 CONTINUE
55.  VK2 = AA * FKF(M) * (ABS(VK1)) * * (EXK(M) - 1.) * EXP( - EAK(M) /
56.  1 RT)*(-C3)
57.  VK3 = VK2
58.  IF (EXK(M) - 1.) 35,30,30
59.  30 VK3 = VK2 * EXK(M)
60.  C PM TIMES FORWARD RATE OF REACTION I (PM=AA)
61.  35 PMR(M) = VK2 * VK1

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62.     PKP(M) = PKP(M) * VK3
63.     PKR(M) = PKR(M) * VK3
64.     RAT(M)=AMAX1(ABS(PKP(M)),ABS(PKR(M)))
65.     RSIG(M)=RAT(M)
66.     IF(KR(7)=1) 40,40,36
67. 36 IF(M=1) 37,37,39
68. 37 WRITE(KOUT,38)
69. 38 FORMAT(2X1HM7X3HLKP6X8HDLKP/DT6X4HPMRR8X4HPMRP9X3HPMP9X3HRAT)
70. 39 WRITE(KOUT,41) M,SUMK,OKPT(M),PKR(M),PKP(M),PMR(M),RAT(M)
71.     1,ELKM(M),DELK(M)
72. 40 CONTINUE
73. 41 FORMAT(I3,2X8E12.5)
74. 45 FORMAT(1X26HA(I,J),B(I),I=1,8,J=1,8 IN)
75. 50 FORMAT(1X12E10.3)
76. 55 FORMAT(1X27HA(I,J),B(I),I=1,8,J=1,8 OUT)
77.     IF (KR(7) = 1) 80,80,65
78. 65 CONTINUE
79.     WRITE(KOUT,50)PRMU
80.     WRITE(KOUT,215)
81.     WRITE(KOUT,50)(EB(I),I=1,18)
82.     WRITE(KOUT,50)(E(I),I=1,18)
83. 70 WRITE(KOUT,45)
84.     DO 75 I=1,ISP2
85. 75 WRITE(KOUT,50)(A(I,J),J=1,ISPO),B(I)
86. 80 CONTINUE
87.     IF(ITS) 105,85,105
88. C*****ORDER REACTIONS
89. 85 DO 86 M=1,MT
90. 86 MA(M)=M
91.     IF(MT=1) 105,105,90
92. 90 K = 0
93.     DO 100 M=2,MT
94.     IF(RSIG(M)=RSIG(M-1)) 100,100,95
95. 95 K = MA(M)
96.     MA(M) = MA(M - 1)
97.     MA(M - 1) = K
98.     DUM1=RSIG(M)
99.     RSIG(M)=RSIG(M-1)
100.    RSIG(M-1)=DUM1
101. 100 CONTINUE
102.     IF (K) 105,105,85
103. C*****START SECOND MAJOR LOOP ON REACTIONS
104. 105 DO 200 MM=1,MT
105.    RSIG(MM)=0.
106.    M = MA(MM)
107. C*****IS IT A CONTROLLING REACTION
108.    IF(ITS) 106,108,106
109. 106 L=LL(MM)
110.    IF(L) 126,126,107
111. 107 DUM=ABS(PRMU(L,M)*RAT(M))
112.    GO TO 130
113. 108 LL(MM)=0
114.    DO 125 L=1,18
115.    IF (PRMU(L,M)) 110,125,110
116. 110 DO 115 K=1,MM
117.    IF (L = LL(K)) 115,125,115
118. 115 CONTINUE
119.    DUM=ABS(PRMU(L,M)*RAT(M))
120.    IF(ABS(PRMU(L,M))-0.001) 125,125,120
121. C* * * YES, IT IS FOR MASS BALANCE L
122. 120 LL(MM) = L
123.    GOTO 130
124. 125 CONTINUE
125. C* * *NO, IT IS NOT, ADD INTO ALL MASS BALANCES

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B28A, KINET

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126. 126 I1=1
127. 127 I2 = I1
128. GOTO 170
129. C*****REARRANGE ACCORDING TO CONTROLLING REACTION
130. 130 RSIG(MM)=DUM/EB(L)*0.1
131. DUM1=PRMU(L,M)
132. PRMU(L,M) = 0.
133. DO 165 I=1,I1
134. IF (PRMU(I,M)) 135,165,135
135. 135 DUM2 = PRMU(I,M) / DUM1
136. IP(1)=1
137. MP = MM + 1
138. IF (MT = MP) 155,140,140
139. 140 DO 150 K=MP,MT
140. MI = MA(K)
141. PRMU(I,MI) = PRMU(I,MI) - DUM2 * PRMU(L,MI)
142. IF (ABS(PRMU(I,MI)) = .001) 145,150,150
143. 145 PRMU(I,MI) = 0.
144. 150 CONTINUE
145. 155 DO 160 K=1,ISPQ
146. 160 A(I + 2,K) = A(I + 2,K) - DUM2 * A(L + 2,K)
147. B(I + 2) = B(I + 2) - DUM2 * B(L + 2)
148. E(I)=E(I)-DUM2*E(L)
149. DUM2 = ABS(DUM2)
150. EB(I) = AMAX1(EB(I),DUM2 * EB(L))
151. 165 CONTINUE
152. PRMU(L,M) = DUM1
153. C*****ADD CONTROLLING REACTION INTO ITS MASS BALANCE
154. I1 = L
155. I2 = L
156. EOL=E(L)+PMR(M)*PRMU(L,M)
157. IF(ITS) 170,230,170
158. 230 DELK(M)=(1.-EASE)*ELKM(M)*AMIN1(1.,ABS(EOL/EB(L)))
159. ELKM(M)=ELKM(M)-DELK(M)
160. IF(PKR(M)=PKP(M)) 240,170,235
161. 235 PKP(M)=PKP(M)*EXP(-DELK(M))
162. GO TO 245
163. 240 PKR(M)=PKR(M)*EXP(DELK(M))
164. 245 PMR(M)=PKR(M)-PKP(M)
165. DO 176 J=1,I1
166. IF(IFC(J)) 171,171,176
167. 171 SUMD = RMU(J,M) * PKR(M) - PMU(J,M) * PKP(M)
168. DO 175 I=1,I2
169. 175 A(I + 2,J + 2) = A(I + 2,J + 2) - SUMD * PRMU(I,M)
170. 176 CONTINUE
171. SUMD = - PKP(M) * DKPT(M) - EAK(M) / RT * PMR(M)
172. DO 180 I=I1,I2
173. DUM1 = PMR(M) * PRMU(I,M)
174. A(I+2,2)=A(I+2,2)-DUM1
175. A(I + 2,1) = A(I + 2,1) + SUMD * PRMU(I,M)
176. E(I)=E(I)+DUM1
177. B(I + 2) = B(I + 2) + DUM1
178. 180 EB(I) = AMAX1(EB(I),ABS(PRMU(I,M) * RAT(M)))
179. EB(I) = AMAX1(EB(I),ABS(E(I)))
180. IF (KR(7) = 1) 200,200,185
181. 185 WRITE(KOUT,215)
182. WRITE(KOUT,50)(EB(I),I=1,I1)
183. WRITE(KOUT,50)(E(I),I=1,I1)
184. 190 WRITE(KOUT,55)
185. DO 195 I=1,ISP2
186. WRITE(KOUT,50)(A(I,J),J=1,ISPQ),B(I)
187. 195 CONTINUE
188. WRITE(KOUT,5)M,I1,I2,L,LL,MM,MA
189. WRITE(KOUT,50)PRMU

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190. 200 CONTINUE
191. C*****MODIFY COEFFICIENTS TO ACHIEVE LINEARITY AS EQUIL IS APPROACHED
192. DO 206 MM=1,MT
193. L=LL(MM)
194. IF(L) 201,206,201
195. 201 M=MA(MM)
196. DUM2=RSIG(MM)
197. IF(ITS) 250,248,250
198. 248 EESE(L)=E(L)*(1.-EASE)/(1.+DUM2)
199. 250 E(L)=E(L)-EESE(L)
200. B(L+2)=B(L+2)-EESE(L)
201. EB(L)=-EB(L)
202. AR=1.
203. EXEL=PKR(M)/PKP(M)
204. IF(EXEL) 191,191,193
205. 191 EXEL=1.E-35
206. IF(PKP(M)-PKR(M)) 192,193,193
207. 192 EXEL=1.E+35
208. 193 CONTINUE
209. EOL=E(L)+DUM2/(DUM2+1.)
210. DUM1=(1.+DUM2)/(1.+RSIG(MM))
211. EB(L)=EB(L)+ABS(DUM1)
212. IF(ABS(EXEL-1.)=.1) 204,204,202
213. 202 DUM1=E(L)/(ELKM(M)+PRMU(L,M))
214. AR=(DUM1+PKR(M))/PMR(M)
215. AR=AMAX1(AR,0.)
216. AR=AMIN1(1.,AR)
217. 204 DO 205 J=1,IS
218. IF(IFC(J)) 203,203,205
219. 203 A(L+2,J+2)=A(L+2,J+2)+ EOL*(PMU(J,M)*(1.-AR)+AR*RMU(J,M))
220. 205 CONTINUE
221. A(L+2,1)=A(L+2,1)-EOL*(DKPT(M)*(1.-AR)-EAK(M)/RT)
222. A(L+2,2)=A(L+2,2)+EOL
223. 206 CONTINUE
224. 215 FORMAT(1X12HEB(I),I=1,IS)
225. IF(KR(7)-1) 225,225,220
226. 220 WRITE(KOUT,55)
227. DO 221 I=1,ISP2
228. 221 WRITE(KOUT,50)(A(I,J),J=1,ISPQ),B(I)
229. WRITE(KOUT,50)(E(I),I=1,IS)
230. 225 RETURN
231. END

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B29A, FIRSTG

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1. CB29A
2. SUBROUTINE FIRSTG
3. COMMON/BLQCOM/ MOA( 60), MOB( 60), NSPEC, FR( 60,15), W(3), LEF( 8)
4. 1, LEFS( 8), PIEASE, LEFW( 8)
5. COMMON/ETACOM/ETA(15), DETA(15), DSQ(14), DCU(14), B1(14), B2(14)
6. 1, LAR(123), BA1(43,18), BA2(30,15)
7. COMMON/INTCOM/ KR(20), KIN, KOUT, MAT1I, MAT2I, MAT1J, MAT2J, NETA, I, IS, N
8. IS, IT, NTIME, NSP, NSPM1, NAM, NLEQ, NNLEQ, NRNL, ITS, KAPPA, CBAR, CASE(15)
9. 2, B(8), MWE, NON, KO(10), ITEM, NITEM, KR17, NBT, NBT2, IDENT, KR9(40)
10. 3, KAUXO, JTIME, JSPEC, MD(3)
11. 4, IDUM(2), KONRFT
12. COMMON/PRMCOM/TIME( 50), PRE(40), PTET( 50), GE( 50), S(40), ROKAP(40)
13. 1, RNOSE, VKAP, NOISC, IDISC(40), NSD(5), MSD(5), ITF( 50), IPRE, RADNG, CONE
14. 2, RADFL( 50), RADR(40), RAD8(40), IRAD
15. COMMON/VARCOM/F(4,15), G(3,15), SP(3,15, 7), ALPH
16. EQUIVALENCE(G(1,1), GW), (ITF(13), IST), (NSD(5), NL)
17. 3 FORMAT(7E10,3)
18. 4 FORMAT (3E10.4,5X15,E10.4)
19. 5 FORMAT(36I2)
20. NUL=0
21. COMMON/UNICOM/UCD, UCE, UCL, UCM, UCP, UCR, UCS, UCT, UCV, ITDK
22. IF (KONRFT.EQ.2) GO TO 116
23. IF (IABS(KR(2)-2)-1) 110,111,112
24. 110 DUM1=(GE(ITEM)-G(1,1))/(G(1,NETA)-G(1,1))
25. DO 113 I=1,NETA
26. G(3,I)=G(3,I)*DUM1
27. G(2,I)=G(2,I)*DUM1
28. 113 G(1,I)=G(1,1)+DUM1*(G(1,I)-G(1,1))
29. GO TO 152
30. 111 READ(KIN,4) ALPH, F(1,1), F(3,1), IST
31. IF(KR(2).EQ.3) KR(2)=MIN0(-IST,-1)
32. ALSO=ALPH*ALPH
33. F(3,1)=F(3,1)*ALSO
34. READ(KIN,3) (F(2,I), I=1,NETA)
35. BA1(MAT1I,1) = F(3,NETA)*ALSO
36. CALL MATS1(BA1(1,1))
37. DO 131 I=1,NETA
38. 131 F(2,I)=F(2,I)*ALPH
39. 116 LL=2
40. L=1
41. I=1
42. DO 134 M=1,MAT1I
43. I=I+1
44. IF(I-NETA) 133,133,132
45. 132 I=LL
46. L=L+LL
47. LL=1
48. 133 F(L,I)=BA1(M,1)-BA1(M,2)*F(1,1)-BA1(M,3)*F(3,1)
49. DO 134 J=4,MAT1J
50. 134 F(L,I)=F(L,I)-BA1(M,J)*F(2,J-3)
51. DO 130 M=1,MAT1I
52. 130 BA1(M,1)=0.
53. BA1(1,1)=1.0
54. CALL MATS2(BA1)
55. DO 138 K=NUL,NSPM1
56. IF (KONRFT.EQ.2) GO TO 117
57. READ(KIN,3) SP(2,1,K), (SP(1,I,K), I=1,NETA)
58. SP(2,1,K)=SP(2,1,K)*ALPH
59. IF(K.NE.NUL) GO TO 139
60. DO 138 I=1,NETA
61. 138 G(1,I)=G(1,I)*UCE

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62.      G(2,1)=G(2,1)*UCE
63.      139 CONTINUE
64.      117 L=2
65.      I=1
66.      DO 138 M=2,MAT2I
67.      I=I+1
68.      IF(I-NETA) 136,136,135
69.      135 I=1
70.      L=L+1
71.      136 SP(L,I,K)=BA1(M,1)*SP(1,NETA,K)-BA2(M,1)*SP(2,1,K)
72.      DO 138 J=2,MAT2J
73.      138 SP(L,I,K)=SP(L,I,K)-BA2(M,J)*SP(1,J-1,K)
74.      DO 140 M=1,MAT2I
75.      140 BA1(M,1)=0.
76.      IF (KONRFT.EQ.2) GO TO 152
77.      IF(NSPM1.GT.0)READ(KIN,5)LEF
78.      GO TO 152
79.      112 IF(NL.EQ.0)READ(KIN,3) GW
80.      GW=GW*UCE
81.      195 ALPH= 4./ETA(KAPPA)
82.      F(1,1)=0.
83.      F(2,1)=0.
84.      F(3,1)= ALPH/ETA(KAPPA)*(CBAR+CBAR+1.)
85.      DUM1=ALPH/ETA(KAPPA)*(CBAR-0.5)
86.      ETAT=ALPH/(F(3,1)-DUM1)
87.      DUM2=0.5/ETAT*ALPH/ETAT
88.      DUM3=ALPH/(ETA(KAPPA)-ETA(NETA))*2*(1.-CBAR)
89.      F(4,1)=-2.*DUM2
90.      DO 114 I=3,KAPPA
91.      IF(ETA(I-1)-ETAT) 108,109,109
92.      108 F(2,I-1)=(F(3,1)-DUM2*ETA(I-1))*ETA(I-1)
93.      F(3,I-1)=F(3,1)-2.*DUM2*ETA(I-1)
94.      F(4,I-1)=-2.*DUM2
95.      GO TO 114
96.      109 F(2,I-1)=ALPH/2.+DUM1*ETA(I-1)
97.      F(3,I-1)=DUM1
98.      F(4,I-1)=0.
99.      114 F(1,I-1)=F(1,I-2)+(F(2,I-2)+F(2,I-1))/2.*DETA(I-2)
100.      DO 107 I=KAPPA,NETA
101.      F(2,I)=ALPH-DUM3*(ETA(NETA)-ETA(I))*2
102.      F(3,I)=2.*DUM3*(ETA(NETA)-ETA(I))
103.      F(4,I)=-2.*DUM3
104.      107 F(1,I)=F(1,I-1)+(F(2,I)+F(2,I-1))/2.*DETA(I-1)
105.      DUM=(GE(ITEM)-GW)/ALPH
106.      DO 115 I=1,NETA
107.      G(1,I)=F(2,I)*DUM+GW
108.      G(2,I)=F(3,I)*DUM
109.      115 G(3,I)=F(4,I)*DUM
110.      152 CONTINUE
111.      9901 FORMAT(1X1P12E10.3)
112.      9904 FORMAT(2X19HDEBUG FIRST GUESSES)
113.      IF(KR(15)) 9902,9903,9902
114.      9902 CONTINUE
115.      WRITE(KOUT,9904)
116.      DO 9906 I=1,4
117.      9906 WRITE(KOUT,9901) (F(I,J),J=1,NETA)
118.      DO 9905 K=NUL,NSPM1
119.      DO 9905 I=1,3
120.      9905 WRITE(KOUT,9901) (SP(I,J,K),J=1,NETA)
121.      9903 CONTINUE
122.      RETURN
123.      END

```

B30A, ERP

```

1.      FUNCTION ERP(X)
2.      TXS=2.*X*X
3.      IF(X=2.) 5,5,15
4.      5 R=0.8
5.      FN=31
6.      DO 10 I=1,15
7.      R=1.-R*TXS/FN
8.      10 FN=FN-2.
9.      ERP=R*X
10.     RETURN
11.     C      SEMI CONVERGENT SERIES FOR LARGE X == INCLUDE 0 TO RAT OF
12.     C      SMALLEST TERM AND RAT TO 1. OF PRIOR TERM IF SMALLEST TERM IS
13.     C      SEVENTH OR PRIOR TERM.
14.     15 IN=(TXS-1.)/2.
15.     RAT=0.68
16.     IF(IN=6) 20,20,25
17.     20 FN=IN+IN-1
18.     R= (TXS-FN-2.)/2.*RAT
19.     R=R/TXS*(FN+2.)+R/RAT-R*RAT
20.     GO TO 30
21.     25 IN=7
22.     R=1.0
23.     FN=13
24.     30 DO 35 I=1,IN
25.     R=1.+R*FN/TXS
26.     35 FN=FN-2.
27.     ERP=R/(2.*X)
28.     RETURN
29.     END

```

B30B, ETIMEF

```

1.      SUBROUTINE ETIMEF(T)
2.      CALL SECOND(T)
3.      T=T-TZ
4.      RETURN
5.      ENTRY ETIME
6.      CALL SECOND(TZ)
7.      RETURN
8.      END

```

B30C, LIAD

```

1.      C      B30C
2.      SUBROUTINE LIAD(L,I,J,C)
3.      COMMON/ERRCOM/FLE( 43),GLE(30),SPLE(30, 6),ELA(253),FLEM,GLEM
4.      1,SPLEM( 6),ELM(14),ELMM,IFLM,IGLM,ISPLM( 6),NELM,I LMM,DFL(43)
5.      2,DGL(30),DSPL(30, 6),FNLE(18),GNLE(15),SPNLE(15, 6),ENL(123)
6.      3,FNLEM,GNLEM,SPNLEM( 6),          ENLMM,IFNLM,IGNLM,ISPNLM( 6)
7.      4,NENLM,INLMM,DFNL(18),DGNL(15),DSPNL(15, 6),DRNL( 8)
8.      COMMON/ETACOM/ETA(15),DETA(15),DSQ(14),DCU(14),R1(14),R2(14)
9.      1,LAR(123),BA1(43,18),BA2(30,15)
10.     COMMON/NONCOM/AM(123,123),DVNL(123),TCW,
11.     1VLNKH,DLPH( 7),DLPK( 6, 7),DTHW,DTKW( 6),FLUXJB( 7)
12.     COMMON/INTCOM/KR(20),KIN,KOUT,MAT1I,MAT2I,MAT1J,MAT2J,NETA
13.     IF(L) 1,3,3
14.     1 ENL(I) = ENL(I) -C*FLE(J)
15.     DO 2 K=1,MAT1J
16.     2 AM(I,K)=AM(I,K)-C*BA1(J,K)
17.     RETURN
18.     3 ENL(I)=ENL(I)-C*SPLE(J,L)
19.     KK=L+MAT2J+MAT1J
20.     DO 4 K=1,MAT2J
21.     KK=KK+1
22.     4 AM(I,KK)=AM(I,KK)-C*BA2(J,K)
23.     RETURN
24.     END

```

B30D, TLEFT

```

1.      SUBROUTINE TLEFT(I)
2.      I=1000000
3.      RETURN
4.      END

```

B30E, DATE

```

1.      SUBROUTINE DATE(I,J)
2.      RETURN
3.      END

```

B30F, TOD

```

1.      SUBROUTINE TOD(I,J)
2.      RETURN
3.      END

```

B30G, SECOND

```

1.      SUBROUTINE SECOND(T)
2.      RETURN
3.      END

```

```

1.  CB36A
2.  SUBROUTINE OGLE(N,XAM,PRM,DPDIM,NUMX,X,P,EM)
3.  DIMENSION XAM(1),X(1),P(1),EM(1),PRM(1),DPDIM(1)
4.  XDIF=X(NUMX)-X(1)
5.  IS=1
6.  2 DO 600 J=1,N
7.  XA=XAM(J)
8.  59 IO=1
9.  IT=1
10.  61 IF(XDIF) 72,60,71
11.  71 IF(XA-X(IS)) 62,63,64
12.  72 IF(X(IS)-XA) 62,63,64
13.  62 IF(IS-1) 671,671,68
14.  68 IS=IS-1
15.  IT=2
16.  GO TO (61,66),IO
17.  672 IS=NUMX
18.  671 I=IS
19.  H=0.
20.  DPDI=EM(I)
21.  GO TO 67
22.  63 PR=P(IS)
23.  DPDI=EM(IS)
24.  GO TO 601
25.  64 IS=IS+1
26.  IF(IS=NUMX) 69,69 ,672
27.  69 IO=2
28.  GO TO (61,65),IT
29.  65 IS=IS-1
30.  I=IS
31.  G=((P(I+1)-P(I))/(X(I+1)-X(I)))-EM(I)/(X(I+1)-X(I))
32.  F=((EM(I+1)-EM(I))/(X(I+1)-X(I)))-2.*G/(X(I+1)-X(I))
33.  H=(F*(XA-X(I+1))+G)*(XA-X(I))
34.  DPDI=(H+H+EM(I)+F*(XA-X(I))*(XA-X(I)))
35.  67 PR=(H+EM(I))*(XA-X(I))+P(I)
36.  601 CONTINUE
37.  DPDIM(J)=DPDI
38.  PRM(J)=PR
39.  600 CONTINUE
40.  60 CONTINUE
41.  4 RETURN
42.  END

```

```

1. SUBROUTINE FILQ3
2. C GENERAL LEAST SQUARE CURVE FIT PROGRAM (FISLER) /RMK PART1
3. COMMON/FITCOM/NC,NDP,NCT,NAUC,JCT(45),S(45),T(45),ETAN(15)
4. 1,DUM(46)
5. COMMON/FSLCOM/X(85),Y(85),PNEW(15),N,ALPH(100),AUC(15),
6. *C(100),NDPS,NL,NLF,NHI,NCP,NCPC,I,J,FX(85)
7. COMMON/NONCOM/AM(123,123)
8. COMMON/TRTCOM/INTL,INTM,INTKN
9. DIMENSION A(100,100),F(56,85)
10. DIMENSION G(4),H(4)
11. EQUIVALENCE (AM(1,1),A(1,1)),(AM(1,83),F(1,1))
12. INTL=0
13. INTM=0
14. INTKN=0
15. N=0
16. 27 DO 44 I=1,NC
17. C(I)=0
18. DO 44 J=1,I
19. 40 A(J,I)=0.
20. NCPC=NC+NCT
21. NCP=NC+1
22. DO 321 I=1,NCPC
23. DO 321 J=NCPC,NCPC
24. 321 A(I,J)=0.
25. NCP=NC
26. 336 DO 34 I=1,NCT
27. NCP=NCP+1
28. C(NCP)=0.
29. IF(JCT(I))332,332,333
30. 332 N=N+1
31. CALL FUNXS (C(NCP),A(1,NCP),S(I),T(I),G,H,JL,JU)
32. GO TO 34
33. 333 CALL TRINT (JCT(I),C(NCP),A(1,NCP),S(I),T(I))
34. 34 CONTINUE
35. NHI=NDP
36. 466 DO 47 K=1,NHI
37. N=N+1
38. CALL FUNXS (FX(K),F(1,K),X(K),Y(K),G,H,JL,JU)
39. DO 47 I=JL,JU
40. FIK=F(I,K)
41. C(I)=C(I)+FX(K)*FIK
42. DO 47 J=JL,I
43. 47 A(J,I)=A(J,I)+FIK*F(J,K)
44. DO 50 J=1,NC
45. JP=J+1
46. DO 50 I=JP,NCPC
47. 50 A(I,J)=A(J,I)
48. N=NCPC
49. RETURN
50. END

```

B50B, FILQ5

```

1.      SUBROUTINE FILQ5
2.      C      GENERAL LEAST SQUARE CURVE FIT PROGRAM (FILQ) / RMK PART 2
3.      COMMON/FITCOM/NC,NDP,NCT,NAUC,JCT(45),S(45),T(45),ETAN(15)
4.      1,DUMP(15),PPNEW(15),PALPH,PPPNEW(15)
5.      COMMON/FSLCOM/X(85),Y(85),PNEW(15),N,ALPH(100),AUC(15),
6.      *C(100),NDPS,NL,NLF,NHI,NCP,NCPC,I,J,FX(85)
7.      COMMON/INTCOM/IDUM1(20),KIN,KOUT,IDUM4(4),NETA,IDUM2(5),NSP,NSPM1,
8.      1IDUM3(5),KAPPA
9.      COMMON/NONCOM/AM(123,123)
10.     DIMENSION A(100,100),F(56,85)
11.     DIMENSION G(4),H(4)
12.     EQUIVALENCE (AM(1,1),A(1,1)),(AM(1,83),F(1,1))
13.     DO 70 I=1,NETA
14.     GXY=0.
15.     GPXY=0.0
16.     GPPXY=0.0
17.     CALL FUNXS(FY,F(1,I),ETAN(I),0,0,G,H,JL,JU)
18.     K=0
19.     63 DO 64 J=JL,JU
20.     K=K+1
21.     GPXY=GPXY+G(K)*ALPH(J)
22.     GPPXY=GPPXY+H(K)*ALPH(J)
23.     64 GXY=GXY+F(J,I)*ALPH(J)
24.     PNEW(I)=GXY
25.     PPNEW(I)=GPXY
26.     PPPNEW(I)=GPPXY
27.     70 CONTINUE
28.     RETURN
29.     END

```

850C, FINEQ

```

1.      SUBROUTINE FINEQ(N)
2.      COMMON/FSLCOM/DUM1(186),X(100),DUM2(15),B(100)
3.      COMMON/NONCOM/AM(123,123)
4.      DIMENSION      A(100,100)
5.      DIMENSION D(100),IP(100)
6.      EQUIVALENCE (A,AM),(D,AM(1,122))
7.      100 FORMAT(25H1SINGULAR, . . . . . STOP)
8.
9.      C
10.     C
11.     C      LU DECOMP.
12.
13.     DO 12 K=1,N
14.     DO 1 I=1,N
15.     1 D(I)=A(I,K)
16.     KM=K-1
17.     IF(KM) 5,5,2
18.     2 DO 4 J=1,KM
19.     IT=IP(J)
20.     A(J,K)=D(IT)
21.     D(IT)=D(J)
22.     JP=J+1
23.     DT=A(J,K)
24.     DO 3 L=JP,N
25.     3 D(L)=D(L)-A(L,J)*DT
26.     4 CONTINUE
27.     IF(K=N) 5,11,11
28.     5 L=0
29.     CT=0.
30.     DO 7 I=K,N
31.     DT=ABS(D(I))
32.     IF(CT-DT) 6,7,7
33.     6 L=I
34.     CT=DT
35.     7 CONTINUE
36.     IF(L) 8,8,9
37.     8 WRITE(6,100)
38.     STOP
39.     9 IP(K)=L
40.     CT=D(L)
41.     A(K,K)=CT
42.     D(L)=D(K)
43.     KP=K+1
44.     DO 10 I=KP,N
45.     10 A(I,K)=D(I)/CT
46.     GO TO 12
47.     11 IP(N)=N
48.     A(N,N)=D(N)
49.     12 CONTINUE
50.
51.     C
52.     C      FORWARD ELIMINATION
53.
54.     DO 13 I=1,N
55.     13 D(I)=B(I)
56.     DO 15 I=1,N
57.     IT=IP(I)
58.     B(I)=D(IT)
59.     D(IT)=D(I)
60.     IPP=I+1
61.     DO 14 J=IPP,N
62.     14 D(J)=D(J)-A(J,I)*B(I)
63.     15 CONTINUE

```

B50C, FINEQ

```

62. C BACK SUBSTITUTION
63. C
64.     X(N)=B(N)/A(N,N)
65.     DO 17 I=2,N
66.       J=N+1-I
67.       JP=J+1
68.       CT=0.
69.       DO 16 K=JP,N
70.         16 CT=CT+A(J,K)*X(K)
71.       17 X(J)=(B(J)-CT)/A(J,J)
72.       RETURN
73.     END

```

B50D, FISLEQ

```

1. SUBROUTINE FISLEQ
2. C GENERAL LEAST SQUARE CURVE FIT PROGRAM (FISLEQ) / RMK
3. COMMON/FITCOM/NC,NDP,NCT,NAUC,JCT(45),S(45),T(45),ETAN(15)
4. COMMON/FSLCOM/X(85),Y(85),PNEW(15),N,ALPH(100),AUC(15),
5. *C(100),NDPS,NL,NLF,NHI,NCP,NCPC,I,J,FX,Y(85)
6. DO 214 I=1,NAUC
7. 214 AUC(I)=ETAN(I+1)
8. CALL FILO3
9. CALL FINEQ(N)
10. CALL FILO5
11. RETURN
12. END

```

B50E, FUNXS

```

1. SUBROUTINE FUNXS (FXY,F,X,Y,G,H,JL,JU)
2. COMMON/FITCOM/NC
3. COMMON/FSLCOM/DUM(286),AUC(15)
4. COMMON/NETCOM/NETAM1,NETAM2,NETAM3
5. COMMON/RFTCOM/DUM1(15),KR10
6. DIMENSION F(1),G(1),H(1)
7. DO 15 I=1,NC
8. 15 F(I)=0.0
9. FXY=Y
10. DO 5 I=1,NETAM2
11. IF (AUC(I).GT.X) GO TO 10
12. 5 CONTINUE
13. C EVALUATES FUNCTION COEFF IN FINAL CURVE SEGMENT
14. J=3*NETAM2
15. IF(KR10-1)22,21,20
16. 20 F(J+1)=X*X
17. F(J+2)=X
18. F(J+3)=1.0
19. G(1)=2.0*X
20. G(2)=1.0
21. G(3)=0.0
22. H(1)=2.0
23. H(2)=0.0
24. H(3)=0.0
25. JL=J+1
26. JU=J+3
27. RETURN
28. 22 J=4*NETAM2
29. 21 F(J+1)=X*X*X
30. F(J+2)=X*X
31. F(J+3)=X
32. F(J+4)=1.0
33. G(1)=3.0*X*X
34. G(2)=2.0*X
35. G(3)=1.0
36. G(4)=0.0
37. H(1)=6.0*X
38. H(2)=2.0
39. H(3)=0.0
40. H(4)=0.0
41. JL=J+1
42. JU=J+4
43. RETURN
44. C EVALUATES FUNCTION COEFF IN ALL BUT FINAL CURVE SEGMENT
45. 10 IF(KR10-1)12,11,11
46. 11 J=3*(I-1)
47. GO TO 20
48. C EVALUATES FUNCTION COEFF FOR FIRST NETAM1 CUBICS
49. 12 J=4*(I-1)
50. GO TO 21
51. END

```

B50F, POINTS

```

1. SUBROUTINE POINTS(JN)
2. COMMON/ETACOM/ETA(15),DETA(15)
3. COMMON/FITCOM/NC,NOP,NCT,NAUC,JCT(45),S(45),T(45),ETAN(15),
4. *P(15),PP(15),PALPH,PPP(15)
5. COMMON/INTCOM/IDU41(20),KIN,KOUT,IDUM4(4),NETA,IDUM2(5),NSP,NSPM1,
6. IDUM3(5),KAPPA
7. COMMON/NETCOM/NETAM1,NETAM2,NETAM3
8. COMMON/F8LCOM/X(85),Y(85),PNEW(15)
9. COMMON/RFTCOM/F2FIX(15),KR10,NPM1,NPOINT,DUM1(34),NETAL,KAPPAL
10. DIMENSION A(15),B(15),C(15),D(15)
11. DIMENSION PFIX(15)
12. C THIS BLOCK CALCULATES THE POLYNOMIAL COEFFICIENTS OF THE EXISTING
13. C CURVES. P REPRESENTS THE INDEPENDENT VARIABLES U/UE,H,AND SP. PP
14. C REPRESENTS THE DERIVATIVES OF THESE QUANTITIES WITH RESPECT TO ETA.
15. C NOTE THAT THIS OPTION ONLY ALLOWS FOR QUADRATIC SOLUTIONS FOR THE
16. C FIRST NETAM2 CURVE SEGMENTS.
17. NLM1=NETAL-1
18. NLM2=NETAL-2
19. DO 110 I=1,NETA
20. PFIX(I)=F2FIX(I)*PALPH
21. IF(KR10,EQ,0)GO TO 401
22. DO 200 N=1,NLM2
23. C QUADRATIC COEFFICIENTS FOR THE FIRST NETAM2 CURVE SEGMENTS
24. A(N)=(P(N+1)-P(N)-DETA(N)*PP(N))/(DETA(N)*DETA(N))
25. B(N)=PP(N)-2.0*A(N)*ETA(N)
26. 200 C(N)=P(N)-(A(N)*ETA(N)+B(N))*ETA(N)
27. N=NLM1
28. GO TO 425
29. C CUBIC COEFFICIENTS FOR THE FIRST NETAM2 CURVE SEGMENTS
30. 401 DO 402 N=1,NLM2
31. A(N)=(PP(N+1)+PP(N)-2.*(P(N+1)-P(N))/DETA(N))/(DETA(N)*DETA(N))
32. B(N)=(PP(N+1)-PP(N)-3.*A(N)*(ETA(N+1)*ETA(N+1)-ETA(N)*ETA(N)))/(2.
33. *DETA(N))
34. C(N)=PP(N+1)+ETA(N+1)*(PP(N)-PP(N+1))/DETA(N)+3.*A(N)*ETA(N)*ETA(N
35. +1)
36. 402 D(N)=P(N)-((A(N)*ETA(N)+B(N))*ETA(N)+C(N))*ETA(N)
37. N=NLM1
38. GO TO 425
39. 425 IF(KR10-1)202,202,201
40. C QUADRATIC COEFFICIENTS FOR THE LAST CURVE SEGMENT
41. 201 A(N)=(P(N+1)-P(N)-DETA(N)*PP(N))/(DETA(N)*DETA(N))
42. B(N)=PP(N)-2.0*A(N)*ETA(N)
43. C(N)=P(N)-(A(N)*ETA(N)+B(N))*ETA(N)
44. GO TO 204
45. C CUBIC COEFFICIENTS FOR THE LAST CURVE SEGMENT
46. 202 A(N)=(PP(N)-2.0*(P(N+1)-P(N))/DETA(N))/(DETA(N)*DETA(N))
47. B(N)=-0.5*(PP(N)/DETA(N)+3.0*A(N)*(ETA(N+1)+ETA(N)))
48. C(N)=(3.0*A(N)*ETA(N)+PP(N)/DETA(N))*ETA(N+1)
49. D(N)=P(N)-((A(N)*ETA(N)+B(N))*ETA(N)+C(N))*ETA(N)
50. GO TO 204
51. 204 CONTINUE
52. C THIS BLOCK EVALUATES THE NEW ETA VALUES BASED UPON PFIX
53. IF(JN-1)502,502,503
54. 502 NSN=2
55. C LOOP ON PFIX
56. DO 250 M=2,NETAM1
57. IF(M-KAPPA)249,248,249
58. 248 ETAN(M)=ETA(KAPPAL)
59. GO TO 250
60. 249 NS=NSN
61. C LOOP ON P TO LOCATE THE CURVE SEGMENT IN WHICH PFIX IS LOCATED

```

B50F, POINTS

```

62. C CHECK FOR ALL CUBIC CURVE -FITS
63. IF(KR10.EQ.0)GO TO 404
64. DO 253 N=NS,NLM1
65. IF(PFIX(M)=P(N))251,252,253
66. C COMPUTATION FOR THE NEW ETA VALUES ON A QUADRATIC SEGMENT
67. 251 NN=N-1
68. ETAN(M)=(-B(NN)+SQRT(B(NN)*B(NN)-4.0*A(NN)*(C(NN)-PFIX(M))))
69. 1/(2.0*A(NN))
70. NSN=N
71. GO TO 250
72. C COMPUTATION FOR THE NEW ETA WHERE PFIX=P
73. 252 ETAN(M)=ETA(N)
74. NSN=N
75. GO TO 250
76. C THE LAST CURVE SEGMENT IS EVALUATED HERE FOR THE NEW ETA VALUES
77. 253 CONTINUE
78. GO TO 413
79. C COMPUTATION OF NEW ETA VALUES ON A CUBIC SEGMENT
80. 404 DO 405 N=NS,NLM1
81. IF(PFIX(M)=P(N))411,412,405
82. 412 ETAN(M)=ETA(N)
83. NSN=N
84. GO TO 250
85. 411 NN=N-1
86. ANF=A(NN)
87. BNF=B(NN)
88. CNF=C(NN)
89. DNF=D(NN)
90. PFM=PFIX(M)
91. ETAF=ETA(NN)
92. 406 ETAF=ETAF+0.02*DETA(NN)
93. POA=((ANF*ETAF+BNF)*ETAF+CNF)*ETAF+DNF
94. IF(POA=PFM)407,408,409
95. 407 POB=POA
96. GO TO 406
97. 409 ETAN(M)=ETAF-((POA=PFM)/(POA=POB))*0.02*DETA(NN)
98. NSN=N
99. GO TO 250
100. C COMPUTATION FOR THE NEW ETA WHERE PFIX=P
101. 408 ETAN(M)=ETAF
102. NSN=N
103. GO TO 250
104. 405 CONTINUE
105. 413 IF(KR10=1)258,258,257
106. C FOR A QUADRATIC FINAL SEGMENT-NEW ETA
107. 257 ETAN(M)=(-B(NLM1)+SQRT(B(NLM1)*B(NLM1)-4.0*A(NLM1)*(C(NLM1)-PFIX(M)
108. 1))))/(2.0*A(NLM1))
109. N=NLM1
110. GO TO 250
111. C FOR A CUBIC FINAL SEGMENT-NEW ETA
112. 258 N=NLM1
113. ANF=A(N)
114. BNF=B(N)
115. CNF=C(N)
116. DNF=D(N)
117. PFM=PFIX(M)
118. ETAF=ETA(N)
119. 285 ETAF=ETAF+0.02*DETA(N)
120. POA=((ANF*ETAF+BNF)*ETAF+CNF)*ETAF+DNF
121. IF(POA=PFM)280,256,286
122. 280 POB=POA
123. GO TO 285
124. 286 ETAN(M)=ETAF-((POA=PFM)/(POA=POB))*0.02*DETA(N)
125. GO TO 250

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B50F, POINTS

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126.      256 ETAN(M)=ETAF
127.      250 CONTINUE
128.      ETAN(NETAL)=ETA(NETAL)
129.      C EVALUATION OF CURVE FIT CONSTRAINTS
130.      C THE UNCHANGING CONSTRAINTS ARE EVALUATED HERE ONLY ONCE
131.      NFIN=NETAM2
132.      NFINR=0
133.      NFINT=0
134.      IF(KR10.EQ.0)NFINT=7
135.      IF(KR10.EQ.0)NFINR=6
136.      IF(KR10.EQ.1)NFIN=NETAM3
137.      DO 781 IC=1,NFIN
138.      ICP=IC+1
139.      JCT(IC)=1+NFINT
140.      S(IC)=ETAN(ICP)
141.      T(IC)=0.0
142.      IF(KR10.GT.0) GO TO 785
143.      ICCP=2*NETAM2+IC
144.      JCT(ICCP)=11
145.      S(ICCP)=ETAN(ICP)
146.      T(ICCP)=0.0
147.      785 ICC=IC+NETAM2
148.      JCT(ICC)=3+NFINR
149.      S(ICC)=ETAN(ICP)
150.      781 T(ICC)=0.0
151.      IF(KR10.NE.1) GO TO 782
152.      IC=NETAM2
153.      ICP=IC+1
154.      JCT(IC)=2
155.      S(IC)=ETAN(ICP)
156.      T(IC)=0.0
157.      IC=IC+IC
158.      JCT(IC)=4
159.      S(IC)=ETAN(ICP)
160.      T(IC)=0.0
161.      782 CONTINUE
162.      C THE CHANGING CONSTRAINTS ARE EVALUATED HERE FOR EACH VARIABLE
163.      403 IC=3*NETAM2+1
164.      IF(KR10.NE.0)IC=2*NETAM2+1
165.      JCT(IC)=0
166.      S(IC)=0.0
167.      T(IC)=P(1)
168.      IC=IC+1
169.      NFINV=0
170.      IF(KR10.EQ.0)NFINV=4
171.      JCT(IC)=6+NFINV
172.      S(IC)=0.0
173.      T(IC)=PP(1)
174.      IC=IC+1
175.      JCT(IC)=0
176.      S(IC)=ETA(NETAL)
177.      T(IC)=P(NETAL)
178.      IC=IC+1
179.      JCT(IC)=5
180.      IF(KR10.EQ.2)GO TO 400
181.      S(IC)=ETA(NETAL)
182.      T(IC)=PP(NETAL)
183.      IC=IC+1
184.      400 JCT(IC)=0
185.      S(IC)=ETA(KAPPAL)
186.      T(IC)=P(KAPPAL)
187.      C THIS BLOCK CREATES AN ARRAY OF POINTS TO BE USED IN FISLEQ TO GENERATE
188.      C A NEW SET OF CURVES BASED UPON THE NEW ETA VALUES
189.      J=2

```

B50F, POINTS

```

190.      K=1
191.      DO 260 M=1,NETAM1
192.      C THE CURVE SEGMENT IS DIVIDED INTO NPOINT EQUAL SEGMENTS
193.      DE=(ETAN(M+1)-ETAN(M))/NPOINT
194.      E=ETAN(M)
195.      DO 261 L=1,NPOINT
196.      265 IF(E-ETA(J))262,263,264
197.      262 JJ=J-1
198.      C WHEN J IS EQUAL TO NETAL, A TEST IS PERFORMED TO DETERMINE WHETHER
199.      C THE LAST SEGMENT IS A CUBIC OR A QUADRATIC FUNCTION
200.      IF(KR10.EQ.0) GO TO 460
201.      IF(J.NE.NETAL) GO TO 267
202.      460 IF(KR10=1)266,266,267
203.      267 Y(K)=(A(JJ)*E+B(JJ))*E+C(JJ)
204.      X(K)=E
205.      K=K+1
206.      GO TO 261
207.      266 Y(K)={(A(JJ)*E+B(JJ))*E+C(JJ))*E+D(JJ)
208.      X(K)=E
209.      K=K+1
210.      GO TO 261
211.      263 Y(K)=P(J)
212.      X(K)=E
213.      K=K+1
214.      J=J+1
215.      GO TO 261
216.      264 J=J+1
217.      GO TO 265
218.      261 E=E+DE
219.      260 CONTINUE
220.      Y(K)=P(NETAL)
221.      X(K)=ETA(NETAL)
222.      KJ=NPOINT*NETAM1+1
223.      CALL FISLEQ
224.      DO 270 I=1,NETA
225.      270 P(I)=PNEW(I)
226.      RETURN
227.      END

```

B50G, REFIT

```

1. SUBROUTINE REFIT
2. COMMON/ETACOM/ETA(15),DETA(15)
3. COMMON/INTCOM/IDUM1(20),KIN,KOUT,IDUM4(4),NETA,IDUM2(5),NSP,NSPM1,
4. IDUM3(5),KAPPA
5. COMMON/VARCOM/F(4,15),G(3,15),SP(3,15,7),ALPH
6. COMMON/FITCOM/NC,NDP,NCT,NAUC,JCT(45),S(45),T(45),ETAN(15),
7. *P(15),PP(15),PALPH,PPP(15)
8. COMMON/RFTCOM/F2FIX(15),KR10,NPM1,NPOINT,DUM1(34),NETAL,KAPPAL
9. COMMON/NETCOM/NETAM1,NETAM2,NETAM3
10. COMMON/UNICOM/UCD,UCE,UCL,UCM,UCP,UCR,UCS,UCT,UCV,ITDK
11. DIMENSION ISPWR(8)
12. 2000 FORMAT (///,5X,12HREFIT CALLED,///)
13. WRITE (KOUT,2000)
14. 2001 FORMAT (2X,2H I,3X,6HETA(I),5X,6H U/UE ,5X,6HG(1,I),2X,8(1X,
15. 17HSP(1,I,,11,1H),1X),//)
16. 2003 FORMAT (2X,2H I,3X,6HETA(I),5X,6HF(3,I),5X,6HG(2,I),2X,8(1X,
17. 17HSP(2,I,,11,1H),1X),//)
18. 2004 FORMAT (2X,2H I,3X,6HETA(I),5X,6HF(4,I),5X,6HG(3,I),2X,8(1X,
19. 17HSP(3,I,,11,1H),1X),//)
20. 2002 FORMAT (2X,I2,11(1PE11,3))
21. PALPH=ALPH
22. C REFIT CONSTANTS ARE EVALUATED HERE
23. NETAM1=NETA-1
24. NETAM2=NETA-2
25. NETAM3=NETA-3
26. IF (KR10-1)779,778,777
27. 777 NC=3*NETAM1
28. NCT=NETAM2*2+4
29. GO TO 780
30. 778 NC=3*NETAM1+1
31. NCT=NETAM2*2+5
32. GO TO 780
33. 779 NC=4*NETAM1
34. NCT=NETAM2*3+5
35. IF (NPOINT.GT.6)NPOINT=6
36. IF (NPOINT.EQ.0)NPOINT=5
37. 780 NDP=NPOINT*NETAM1+1
38. NPM1=NPOINT-1
39. NAUC=NETAM2
40. DO 781 I=1,15
41. P(I)=F(2,I)
42. 781 PP(I)=F(3,I)
43. CALL POINTS(1)
44. DO 782 I=1,15
45. F(3,I)=PP(I)
46. F(4,I)=PPP(I)
47. 782 F(2,I)=P(I)
48. F(2,I)=0.0
49. DO 783 I=1,15
50. P(I)=G(1,I)
51. 783 PP(I)=G(2,I)
52. CALL POINTS(2)
53. DO 784 I=1,15
54. G(3,I)=PPP(I)
55. G(2,I)=PP(I)
56. 784 G(1,I)=P(I)
57. IF (NSPM1.EQ.0) GO TO 788
58. DO 787 J=1,NSPM1
59. DO 785 I=1,15
60. P(I)=SP(1,I,J)
61. 785 PP(I)=SP(2,I,J)

```

B50G, REFIT

```

62.      CALL POINTS (2)
63.      DO 786 I=1,15
64.          SP(2,I,J)= PP(I)
65.          SP(3,I,J)=PPP(I)
66.      786 SP(1,I,J)=P(I)
67.      787 CONTINUE
68.      788 CONTINUE
69.      799 DO 508 I=1,15
70.      508 ETA(I)=ETAN(I)
71.          DO 800 I=1,8
72.      A00 ISPWR(I)=I
73.          WRITE (KOUT,2001) ISPWR
74.          DO 801 I=1,NETA
75.          URAT=F(2,I)/ALPH
76.          GRAT=G(1,I)/UCE
77.      A01 WRITE(KOUT,2002)I,ETA(I),URAT,GRAT,(SP(1,I,J),J=1,NSPM1)
78.          RETURN
79.      END

```

B50H, TRINT

```

1.      SUBROUTINE TRINT (I,GSTUV,G,S,T)
2.      C TRINT CONVERTS THE CURVE FIT CONSTRAINTS INTO COEFFICIENTS FOR THE
3.      C UNKNOWN A'S
4.          DIMENSION G(3)
5.          COMMON/RFTCOM/DUM1(15),KR10
6.          COMMON/FITCOM/NC
7.          COMMON/NETCOM/NETAM1,NETAM2,NETAM3
8.          COMMON/TRTCOM/L,M,KN
9.          GSTUV=0.0
10.         DO 10 K=1,NC
11.             10 G(K)=0.0
12.         C QUAD-QUAD INTERIOR POINT MATCH
13.         GO TO(101,102,103,104,105,106,107,108,109,110,111),I
14.         101 L=L+3
15.             G(L-2)=S*S
16.             G(L-1)=S
17.             G(L)=1.0
18.             G(L+1)=-S*S
19.             G(L+2)=-S
20.             G(L+3)=-1.0
21.             RETURN
22.         C QUAD-CUBIC INTERIOR POINT MATCH
23.         102 L=L+3
24.             G(L-2)=S*S
25.             G(L-1)=S
26.             G(L)=1.0
27.             G(L+1)=-S*S*S
28.             G(L+2)=-S*S
29.             G(L+3)=-S
30.             G(L+4)=-1.0
31.             RETURN
32.         C QUAD-QUAD INTERIOR SLOPE MATCH
33.         103 M=M+3
34.             G(M-2)=2.0*S
35.             G(M-1)=1.0
36.             G(M+1)=-2.0*S
37.             G(M+2)=-1.0
38.             RETURN
39.         C QUAD-CUBIC INTERIOR SLOPE MATCH
40.         104 M=M+3
41.             G(M-2)=2.0*S
42.             G(M-1)=1.0
43.             G(M+1)=-3.0*S*S
44.             G(M+2)=-2.0*S
45.             G(M+3)=-1.0
46.             RETURN
47.         C FINAL CUBIC SLOPE=OLD VALUE AT OUTER EDGE
48.         105 IF(KR10-1)21,20,20
49.         20 J=NETAM2*3
50.             GO TO 22
51.         21 J=NETAM2*4
52.         22 G(J+1)=3.0*S*S
53.             G(J+2)=2.0*S
54.             G(J+3)=1.0
55.             RETURN
56.         C INITIAL QUAD SLOPE= OLD VALUE AT INNER EDGE
57.         106 GSTUV=T
58.             G(1)=2.0*S
59.             G(2)=1.0
60.             RETURN
61.         C ENTRY 107 IS NOT USED IN THIS VERSION

```

B50H, TRINT

```

62.      107 RETURN
63.      C      CUBIC CUBIC INTERIOR POINT MATCH
64.      108 L=L+4
65.          G(L-3)=S*S*S
66.          G(L-2)=S*S
67.          G(L-1)=S
68.          G(L)=1.0
69.          G(L+1)=-S*S*S
70.          G(L+2)=-S*S
71.          G(L+3)=-S
72.          G(L+4)=-1.0
73.      RETURN
74.      C      CUBIC-CUBIC INTERIOR SLOPE MATCH
75.      109 M=M+4
76.          G(M-3)=3.*S*S
77.          G(M-2)=2.*S
78.          G(M-1)=1.0
79.          G(M+1)=-3.*S*S
80.          G(M+2)=-2.*S
81.          G(M+3)=-1.
82.      RETURN
83.      C      INITIAL CUBIC-SLOPE=OLD VALUE AT INNER EDGE
84.      110 GSTUV=T
85.          G(1)=3.*S*S
86.          G(2)=2.*S
87.          G(3)=1.0
88.      RETURN
89.      C      CUBIC-CUBIC INTERIOR SLOPE DERIVATIVE MATCHING
90.      111 KN=KN+4
91.          G(KN-3)=6.*S
92.          G(KN-2)=2.
93.          G(KN+1)=-6.*S
94.          G(KN+2)=-2.
95.      RETURN
96.      END

```

4.4 FORTRAN VARIABLE LIST

All of the Fortran variables are listed and defined in this section. The routines within which the variables are used, other than in a common block, are indicated beneath the definition of the variable (e.g., 08B, 11A, where the numbers refer to the element number (B08B, B11A)). The variables are further identified in the right-hand column according to the following system:

- An L or an L followed by a name indicates that the variable is local and used in many subroutines or is local to the subroutine named.
- A C followed by a name indicates that the variable is in a labeled common of that name.
- An E followed by a name indicates that the variable is equivalenced to a variable in the named common block.

In some cases the same quantity has different Fortran names in different subroutines. This only occurs for some variable used in the chemistry routines (EQUIL, PROPS, THERM, MATER, KINET, CRECT, INPUT). In the definition of the variable name its other name is also used and identified in the following manner:

- An asterisk (*) indicates that the variable is valid only in the chemistry routines.
- A plus (+) indicates that the variable is not valid in the chemistry routines.

(For an example of the above, see FAMOA, MOA. FAMOA is valid only in the chemistry routines.)

In the Fortran variables list, the subscripts have the following convention:

- I = Ith nodal point or nodal segment
- J = Jth species (molecular, atomic, ionic and condensed)
- K, KK = Kth or KKth element, base species, or related quantity
- L = Lth streamwise station
- N, NN = Other meanings, defined as used

Finally, variables referred to in the definitions are Fortran variable names except where specifically identified otherwise (e.g., in the definition of AM(N,NN), (BNL) is not a Fortran variable name but is defined in the text). Defining equations for certain variables have been collected and are given in Table 4-1. These equations are referenced by number in the variables list.

TABLE 4-1. SUMMARY OF DEFINING EQUATIONS FOR FORTRAN VARIABLES

$$1. *ALP(K) = \alpha_k = \sum_j v_{jk} n_j$$

where v_{jk} is the number of atoms of element k in species j and n_j is the number of moles of species j . Then α_k is the amount of element k and is a conserved quantity.

$$2. ALPH = \alpha_H = \hat{n}/\bar{n} \text{ (see Equation (3-2))}$$

$$3. D1 = d_1 = -\frac{2}{\ell^{\Delta_{\ell-1}}}, D2 = d_2 = 0 \text{ (Equation (3-34))}$$

where $\ell^{\Delta_{\ell-1}}$ is given by Equation (5)

$$4. D1 = d_1 = -2 \frac{\ell^{\Delta_{\ell-2}}}{\ell^{\Delta_{\ell-1}} \ell^{-1\Delta_{\ell-2}}} \text{ (Equation (3-35))}$$

$$D2 = d_2 = 2 \frac{\ell^{\Delta_{\ell-1}}}{\ell^{\Delta_{\ell-2}} \ell^{-1\Delta_{\ell-2}}}$$

where $\ell^{\Delta_{\ell-1}}$ is given by Equation (5)

$$5. \ell^{\Delta_{\ell-1}} = \ln \xi_\ell - \ln \xi_{\ell-1} = \ln (\xi_\ell / \xi_{\ell-1}) \text{ (Equation (3-36))}$$

$$6. \begin{vmatrix} AL & BL \\ \hline ANL & BNL \end{vmatrix}_{IXJ} \begin{vmatrix} \Delta VL \\ \hline \Delta VNL \end{vmatrix}_{JX1} = - \begin{vmatrix} EL \\ \hline ENL \end{vmatrix}_{IX1} \text{ (Equation (3-85))}$$

$$7. BA1(N,NN) = AL_{FF}^{-1} \cdot BL_{FF} \text{ where } AL_{FF} + BL_{FF} \text{ are shown in Figure 3-1.}$$

$$8. BA2(N,NN) \text{ similar to } BA1$$

$$9. BETAM(L) = \beta_p = -\frac{2}{\rho_1 u_1^2} \frac{dP}{d \ln \xi} \text{ (Equation (3-13))}$$

* These numbers correspond to the equation reference numbers used in the Fortran variables definitions.

$$10. \text{ BETAV}(L) = \beta_v = 2 \frac{d \ln u_1}{d \ln \xi} \quad (\text{Equation (3-12)})$$

$$11. \text{ DZ} = d_o = \frac{2}{\ell^{\Delta_{\ell-1}}} \quad (\text{Equation (3-34)})$$

where $\ell^{\Delta_{\ell-1}}$ given by Equation (5)

$$12. \text{ DZ} = d_o = 2 \frac{\ell^{\Delta_{\ell-1}} + \ell^{\Delta_{\ell-2}}}{\ell^{\Delta_{\ell-1}} \ell^{\Delta_{\ell-2}}} \quad (\text{Equation (3-35)})$$

where $\ell^{\Delta_{\ell-1}}$ given by Equation (5)

$$13. \text{ C3M}(L) = 1/\alpha^* = \frac{\sqrt{2\xi}}{\rho_1 u_1 \mu_1 r_o^K} \quad (\text{Equation (3-19)})$$

$$14. \text{ CPTIL} = \tilde{C}_p = \sum_i Z_i C_{p_i} \quad (\text{Equation (2-21)})$$

$$15. \text{ CT} = C_t \text{ used in: } D_i^T = \frac{C_t \rho \bar{D} \mu_2}{\mu_1 \eta} (Z_i - K_i) \quad (\text{Equation (2-20)})$$

$$16. \text{ D2UEDGE} = f''_{\text{edge}} = \alpha_H \left\{ f' \frac{d \frac{u}{u_1}(f, \xi)}{df} \right\}$$

$$17. \text{ DLX2} = \ell^{\Delta_{\ell-2}}$$

where Δ defined in Equation (5)

$$18. \text{ DMU4H} = \frac{\partial \mu_4}{\partial h} \quad \text{where } \mu_4 \text{ given by Equation (2-21)}$$

$$19. \text{ DMU4K} = \frac{\partial \mu_4}{\partial k} \quad \text{where } \mu_4 \text{ given by Equation (2-21)}$$

$$20. \text{ DUEGE} = f'_{\text{edge}} = \alpha_H \frac{u}{u_1}$$

$$21. \text{ DVNL}(N) = [\Delta \text{VNL}_a]_I \text{ EASE}$$

corrections to primary nonlinear variables, where ΔVNL_a defined by Equation (3-90)

$$22. \text{ ETA}(I) = \eta = \frac{u_1}{\alpha_H \sqrt{2\xi}} \int_0^y \rho r^K dy \quad (\text{Equation (3-6)})$$

$$23. \text{ FF}(J) = F_j \text{ used in } \mathcal{A}_{ij} = \frac{\bar{D}}{F_i F_j} \quad (\text{Equation (2-19)})$$

$$24. \text{ GAM} = \gamma$$

$$\gamma = \left(\frac{\partial \ln P}{\partial \ln \rho} \right)_S = \left\{ 1 + \left(\frac{\partial \ln m}{\partial \ln P} \right)_{T,K} - \frac{R}{m C_p} \left[1 - \left(\frac{\partial \ln m}{\partial \ln T} \right)_{P,K} \right]^2 \right\}^{-1}$$

$$25. \text{ GAMF}(K) = \gamma_{fk} = \frac{\alpha^*}{m_k} \frac{\partial j_k^*}{\partial (\rho v)_w}$$

where j_k^* given in Equation (35)

$$26. \text{ GAMH}(k) = \gamma_{hk} = \frac{\alpha^*}{m_k} \frac{\partial j_k^*}{\partial h}$$

where j_k^* given in Equation (35)

$$27. \text{ GAMK}(K, KK) = \gamma_{K, kk} = \frac{\alpha^* m_k}{m_{kk}} \frac{\partial j_{kk}^*}{\partial \tilde{K}_k}$$

where j_{kk}^* given by Equation (35)

$$28. \text{ HTIL} = \tilde{h} = \sum_i Z_i h_i \quad (\text{Equation (2-21)})$$

29. $\Omega_{ij}^{(1,1)*}$ used in calculation of DBAR

30. $SC(1) = \overline{Sc} = \frac{\mu_1 \mu_m}{\rho D \mu_2}$ (Equation (2-55))

31. $SLAM(K) = \sum_j P_j \lambda_{jk}$ and $\lambda_{jk} = VLAM(J,K) = \sum_m \gamma_{Kmi} v_m$

where γ_{Kmi} given by Equation (27)

32. $VMU1 = \mu_1 = \sum_j x_i F_i$ (Equation (2-21))

(Note: μ_1 is also used for the reference viscosity which is often $\mu_e(\xi)$. VMU1 is used only in the transport properties formulation.)

33. $VMU2 = \mu_2 = \sum_i \frac{m_i x_i}{F_i}$ (Equation (2-21))

34. $VMU3 = \mu_3 = \sum_i \frac{Z_i}{m_i}$ (Equation (2-21))

35. $WALLJ(K) = j_k^* = \frac{C}{\alpha_H \overline{Sc}} [\tilde{Z}_k' + (\tilde{Z}_k - \tilde{K}_k) \mu_4']$ (Equation (3-24))

36. $WALLQ = q_a^*$ (see Equation (3-22))

37. $XG(N) = XP_n$, $n = 1, 2, 3, 4$; $P = H_T$

where XP_n given by Equation (3-39)

$$38. \quad XG(5) = \int_{i-1}^1 f' p d\eta \quad (\text{Equation (3-38)})$$

where $p = H_T$

$$39. \quad XI(L) = \xi = \int_0^s \mu_1 \rho_1 u_1 r_o^{2K} ds \quad (\text{Equation (3-6)})$$

$$40. \quad XM(N) = XP_n, \quad n = 1, 2, 3, 4; \quad p = f'$$

where XP_n given by Equation (3-39)

$$41. \quad XM(5) = \int_{i-1}^i f' p d\eta \quad (\text{Equation (3-38)})$$

where $p = f'$

$$42. \quad XSP(N,K) = XP_n, \quad n = 1, 2, 3, 4; \quad p = \tilde{K}_k$$

where XP_n given by Equation (3-39)

$$43. \quad XSP(5,K) = \int_{i-1}^i f' p d\eta \quad (\text{Equation 3-38))}$$

where $p = \tilde{K}_k$

$$44. \quad ZG(N,I) = ZP_n, \quad n = 1, 2, 3, 4; \quad p = H_T$$

where ZP_n given by Equation (3-45)

$$45. \quad ZK(K) = \tilde{Z}_k = \sum_i a_{ki} Z_i \quad (\text{Equation (2-21)})$$

$$46. \quad ZM(N,I) = ZP_n, \quad n = 1, 2, 3, 4; \quad p = f'$$

where ZP_n given by Equation (3-45)

$$47. \quad ZSP(N,I,K) = ZP_n, \quad n = 1, 2, 3, 4; \quad p = \tilde{K}_k$$

where ZP_n given by Equation (3-45)

<u>Variable Name</u>	<u>Definition (Where Actively Used)</u>	<u>Common Block</u>
A(N,NN)	ERROR COEFFICIENT ARRAY IN CHEMISTRY SOLUTION, N PERTAINS TO EQUATION WHEREAS NN PERTAINS TO VARIABLE. (05B,09B,11B,20A,22A,25A,28A,50A)	C EQTCOM
A1(N)	DUMMY VARIABLE, DEFINED IN INPUT	L INPUT
AA	PRODUCT OF PRESSURE TIMES MOLECULAR WEIGHT, (20A,21A,22A,23A,25A,28A)	C EQTCOM
AB	LOCALLY DEFINED VARIABLE	L SLOPR
ABB	LOCALLY DEFINED VARIABLE	L SLOPR
ARECK	A+ IN BUSHNELL-BECKWITH TURBULENT MODEL	L TRMBL
ABER	ABSOLUTE VALUE OF RATIO OF A MASS BALANCE ERROR TO LARGEST TERM IN THAT MASS BALANCE.	L MATER
AB9VA	ABSOLUTE VALUE OF CONTRIBUTION OF A SPECIES TO A MASS BALANCE.	L MATER
ABX	ABSOLUTE VALUE OF LOG CORRECTION ON TEMPERATURE.	L CRECT
AC	LOCALLY DEFINED VARIABLE	L SLOPO
ACC	LOCALLY DEFINED VARIABLE	L SLOPO
ACCP	ACCELERATION PARAMETER, DEFINED IN OUTPUT	L OUTPUT
ACEB	A+ IN CEBECI TURBULENT MODEL	L TRMBL
ACH	MACH NUMBER	L OUTPUT
ADUM	COEFFICIENT IN SURFACE KINETIC RELATION FOR MATERIAL BEING CONSIDERED UNDER KR(9) = 5 OR 6 (SEE INPUT INSTRUCTIONS). *NOT USED IN BLIMPJ* (05C,09A)	C CRBCOM
AF	LOCALLY DEFINED VARIABLE	L TRMBL
ALF	DERIVATIVE OF LOG MOLECULAR WEIGHT WITH RESPECT TO LOG TEMPERATURE AT CONSTANT PRESSURE.	L EQUIL
ALP(K)	INPUT MASS QUANTITY OF ELEMENTS, EQ(1) (05C,20A,22A)	C EQTCOM
ALPH	NORMALIZING PARAMETER FOR BOUNDARY LAYER NORMAL COORDINATE, SEE EQ. (2) (04A,05B,06A,08A,10A,11A,19A,19T,29A,50G)	C VARCOM
ALPHO	D1*ALPH + D2*HALPH WHERE D1 AND D2 ARE DEFINED BY EQ(3) OR (4) (05B,10A)	C HISCOM
ALPT(N)	NUMBER OF ATOMS OF AN ELEMENT WITH ATOMIC NUMBER JAT(N) IN A SPECIES.	L INPUT
ALSO	ALPH**2	L FIRSTG
AM(N,NN)	COEFFICIENTS IN THE MATRIX DEFINED AS (BNL) IN EQ(6)	C NONCOM

(05B,05C,12B,13B,19A,19T,20A,22A,30C,50A,50B,50C)

AMDA	ALPHANUMERIC VARIABLE, FIRST OF THREE PORTIONS OF SPECIES NAME	L INPUT
AMOB	ALPHANUMERIC VARIABLE, SECOND OF THREE PORTIONS OF SPECIES NAME.	L INPUT
AMOC	ALPHANUMERIC VARIABLE, THIRD OF THREE PORTIONS OF SPECIES NAME.	L INPUT
AMUS	$VN(J) * WTM(J) / (FF(J) * (WDZ - VN(J) * FF(J) * WDZ))$ SUMMED OVER ALL SPECIES N *.	L PROPS
AP(N)	DUMMY VARIABLE EQUIVALENT TO TEMCOM	L OUTPUT
APE(N,NN)	SAVED ARRAY A(N,NN) DURING INVERSION, (20A)	L EQUIL
AR	WEIGHTING FACTOR IN LINEARIZING EQUILIBRIUM ASPECT OF KINETICALLY CONTROLLED MASS BALANCE.	L KINET
AREA	AREA PER UNIT MASS FLOW DURING EXPANSION.	L EQUIL
AREA	WALL AREA USED IN OUTPUT	L OUTPUT
ARPH	ELEMENTAL MASS FRACTION OF ATOM.	L EQUIL
ARPHM	MAXIMUM CONTRIBUTION TO CALCULATION OF AN ARPH.	L EQUIL
ASTAR	A* USED IN TRANSPORT PROPERTIES	L PROPS
ASU	FIRST FOUR CHARACTERS OF ALPHANUMERIC NAME OF ASSIGNED SURFACE SPECIES (05B,09A)	C CRBCOM
ATA(K)	ALPHANUMERIC VARIABLE, FIRST OF THREE PORTIONS OF ELEMENT NAME. (11A,24A)	C EQPCOM
ATB(K)	ALPHANUMERIC VARIABLE, SECOND OF THREE PORTIONS OF ELEMENT NAME. (11A,24A)	C EQPCOM
ATC(K)	ALPHANUMERIC VARIABLE, THIRD OF THREE PORTIONS OF ELEMENT NAME. (24A)	C EQPCOM
ATEMP	ABSOLUTE VALUE OF DTEMP	L NONCFR
B(N)	ERRORS USED WITH COEFFICIENTS TO YIELD CORRECTIONS IN CHEMISTRY ITERATIONS, IDENTICAL TO BR*. (20A,22A,23A,28A)	C EQTCOM
B(N)	ARRAY OF CONSTANTS DEFINED IN RLIMP, IDENTICAL TO BR*. (02A,04A,06A,27A)	C INTCOM
B1	SAVED VALUE OF B(1) DURING INVERSION. EQUALS SURFACE EQUILIBRIUM ERROR FOR THAT OPTION. (20A)	L EQUIL
B1(I)	$DSQ(I-1)/6$ (12B,27A)	C ETACOM

B2(I)	D9Q(I-1)/3 (13B,27A)	C ETACOM
BA1(N,NN)	MATRIX (BLFF) PREMULTIPLIED BY INVERSE OF (ALFF) (SEE EQ (7).) (05B,06A,27A,29A,30C)	C ETACOM
BA2(N,NN)	MATRIX (BLHH) OR (BLKK) PREMULTIPLIED BY INVERSE OF (ALHH) OR (ALKK), RESPECTIVELY. (SEE EQ (8).) (05B,27A,29A,30C)	C ETACOM
BASMOL	MOLECULAR WEIGHT OF REFERENCE SPECIES IN DIFFUSION FACTOR CALCULATIONS (24A,25A)	C FOTCOM
BBECK	CONSTANT INPUT AS CLNUM IN BUSHNELL-BECKWITH MODEL	L TRMBL
BDUM	COEFFICIENT IN SURFACE KINETIC RELATION FOR MATERIAL BEING CONSIDERED UNDER KR(9) = 5 OR 6 (SEE INPUT INSTRUCTIONS). *NOT USED IN BLIMPJ* (05C,09A)	C CRBCOM
BETA	BETAM(L) (05B,08A,10A,11A)	C HISCOM
BETAM(L)	STREAMWISE PRESSURE GRADIENT PARAMETER DEFINED BY EQ(9) (07A,09B,10A)	C HISCOM
BETAV(L)	STREAMWISE VELOCITY GRADIENT PARAMETER DEFINED BY EQ(10). (07A,09B,10A)	C HISCOM
BETH	DERIVATIVE OF LOG MOLECULAR WEIGHT WITH RESPECT TO LOG PRESSURE AT CONSTANT TEMPERATURE.	L EQUIL
BF	LOCALLY DEFINED VARIABLE	L TRMBL
BIP	NOMINALLY ZERO, SET TO 1. TO PREVENT PREMATURE CONVERGENCE	L NONCFR
BLOW	BLOWING PARAMETER BASED ON GAS MASS FLUX GIVEN BY RHOVW(19,1)/(C3 * CH). (11A)	C OUTCOM
BLOWCH	CHAR FLUX NORMALIZED BY HEAT TRANSFER COEFFICIENT	L OUTPUT
BLOWPG	PYROLYSIS GAS FLUX NORMALIZED BY HEAT TRANSFER COEFFICIENT	L OUTPUT
BLQEQV	VARIABLE EQUIVALENCED TO BLQCOM FOR DUMPING PURPOSES	L DUMCOM
B3(N)	SAVED ARRAY OF B(N) DURING INVERSION	L EQUIL
BSU	SECOND FOUR CHARACTERS OF ALPHAMERIC VALUE OF ASSIGNED SURFACE SPECIES (05B,09A)	C CRBCOM
BULP	LOG (BUMP)	L CRECT
BUMEQV	VARIABLE EQUIVALENCED TO BUMCOM FOR DUMPING PURPOSES	L DUMCOM
BUMP	CONTRIBUTION TO DAMPING FACTOR EASE RESULTING FROM SIGN CHANGES IN CRITICAL ERRORS. (05B)	C BUMCOM
BUMP	10**4 * P, CONSTRAINTS ON CORRECTIONS ARE RELAXED FOR PARTIAL PRESSURES BELOW THIS VALUE.	L CRECT

C(K)	GRAM ATOMS OF ELEMENT K IN A MOLECULE. (50A)	L INPUT
C1	$1.7 + DZ$ WHERE DZ IS DEFINED BY EQ(11) OR (12) (05A,05B,05C,08A,10A,11A,19A)	C HISCOM
C2	$-(1+2*DZ)$ WHERE DZ IS DEFINED BY EQ(11) OR (12) (05B,10A,12B,13B)	C HISCOM
C3	CYM(L) (05B,05C,08A,10A,11A,19A,28A)	C HISCOM
C3M(L)	$-1/ALPHASTAR$ WHERE ALPHASTAR IS THE FLUX NORMALIZING PARAMETER DEFINED BY EQ (13) (07A,10A,19T)	C HISCOM
C4	$BETAV + 1 + DZ$ WHERE DZ IS DEFINED BY EQ(11) OR (12) (05B,10A)	C HISCOM
C5	$1.7/ALPH$ (05B,08A,13B)	C COECOM
C6	$BETA * ALPH**2$ (05B,08A,12B,13B)	C COECOM
C7	$-(UE(L)**2)/((ALPH**2)*25036.5)$ (05B,19A,19T)	C COECOM
C8	$ALPHD/ALPH$ (05B,13B)	C COECOM
C9	$BETA+1.+DZ = ALPHD/ALPH$ (05B,12B,13B)	C COECOM
C10	$C7 * F(2, I)$ (05B,08A,12B,13B,19A)	C COECOM
C10W	WALL VALUE OF C10	L TRMBL
C11	DEFINED IN ICOEFF (08A)	C COECOM
C12	DEFINED IN ICOEFF (08A,12B,13B)	C COECOM
C13	$C7 * F(3, I)$ (05B,08A,13B,19A)	C COECOM
C14	$(1.+DZ)*F(1, I)+HF(1, 5)$ (08A,12B,13B)	C COECOM
C15	$PR(I)=1$ (08A)	C COECOM
C16	$1.7/PR(I)$ (08A)	C COECOM
C17	$1.7/SC(I)$ (08A)	C COECOM
C18	$CTR*T(I)$ (08A)	C COECOM

C19	CAPC(I)/(ALPH*SC(I)) (08A)	C COECON
C20	CAPC(I)/(ALPH*PR(I)) (08A)	C COECON
C21	DEFINED IN ICOEFF (08A)	C COECON
C22	DEFINED IN ICOEFF (08A)	C COECON
C23	DEFINED IN ICOEFF (08A)	C COECON
C24	DEFINED IN ICOEFF (08A)	C COECON
C25	DEFINED IN ICOEFF (08A)	C COECON
C26	RHOE(L)/RHO(I) (08A,12B,13B,19A)	C COECON
C27	DRHOM (19T)	C COECON
C28	DEFINED IN ICOEFF (08A,19A,19T)	C COECON
C31	DEFINED IN ICOEFF (08A)	C COECON
C32	NORMALIZED DIFFUSIVE HEAT FLUX CALCULATED IN ICOEFF (05B,08A,19A,19T)	C COECON
C43	DEFINED IN ICOEFF (08A,12B,13B)	C COECON
C53	RHOP(I)/RHO(I) (08A,12B,13B,19A)	C COECON
C56	F(2,I)/ALPH (08A,12B,13B,19A)	C COECON
C56W	WALL VALUE OF C56	L TRMBL
C63	DEFINED IN IMONE, (12B)	C COECON
C72	DEFINED IN IMONE, (12B,13B)	C COECON
C73	(1,+DZ) * F(2,I) (08A,12B)	C COECON
C74	DEFINED IN ICOEFF (08A,12B,13B)	C COECON
C75	DEFINED IN ICOEFF (08A,12B,13B)	C COECON
C76	(1,+DZ) * G(1,I) (08A,12B,13B)	C COECON

C77	DEFINED IN ICoeff (08A,12B,13B)	C COECOM
C78	DEFINED IN ICoeff (08A,12B,13B)	C COECOM
C79	DEFINED IN ICoeff (08A)	C COECOM
C80	DEFINED IN ICoeff (08A,12B,13B)	C COECOM
C81	DEFINED IN ICoeff (08A,12B,13B)	C COECOM
C82	DEFINED IN ICoeff (08A,12B,13B)	C COECOM
C83	DEFINED IN ICoeff (08A,12B,13B)	C COECOM
C84	DEFINED IN ICoeff (08A,12B,13B)	C COECOM
C85	DEFINED IN ICoeff (08A)	C COECOM
C86	DEFINED IN ICoeff (08A,12B,13B)	C COECOM
C87	DEFINED IN ICoeff (08A,12B,13B)	C COECOM
C88	DEFINED IN ICoeff (08A,12B,13B)	C COECOM
C89	BETA * (ALPH **2) * CRHO1	L IONLY
C89	-C3 * ALPH * VMUE(L)	L OUTPUT
CAPC(I)	PRODUCT OF DENSITY AND VISCOSITY NORMALIZED BY EDGE VALUE. (08A,11A,14A,19A,25A)	C PRPCOM
CASE(N)	ALPHANUMERIC NAME OF CASE. (09A,11B)	C INTCOM
CBAR	VALUE OF THE VELOCITY RATIO AT BOUNDARY LAYER NODE KAPPA. (05B,07B,09A,29A)	C INTCOM
CBECK	CONSTANT INPUT AS ELCON IN BUSHNELL-BECKWITH MODEL	L TRMBL
CCEB	CONSTANT INPUT AS ELCON IN CEBECI MODEL	L TRMBL
CDUM	COEFFICIENT IN SURFACE KINETIC RELATION FOR MATERIAL BEING CONSIDERED UNDER KR(9) = 5 OR 6 (SEE INPUT INSTRUCTIONS). *NOT USED IN BLIMPJ* (05C,09A)	C CRBCOM
CF	MOMENTUM TRANSFER COEFFICIENT GIVEN BY CAPC(1)/ALPH * VMUE(1S)/C89*F(3,1) (11A)	C OUTCOM
CG(MS)	TOTAL ENTHALPY CORRESPONDING TO SF(MS)	C EDGCOM

	(05B,07A)	
CGE	USED IN ENERGY LAYER OPTION. *NOT USED IN BLIMPJ*	C EDGCOM
CGEP	USED IN ENERGY LAYER OPTION. *NOT USED IN BLIMPJ*	C EDGCOM
CGP(MS)	DERIVATIVE OF CG(MS) WITH RESPECT TO ETA (05B,07A)	C EDGCOM
CH	HEAT TRANSFER COEFFICIENT BASED ON ENTHALPY POTENTIAL, GIVEN BY $-WALLO/(C3*(G(1,NETA)-G(1,1)))$ (11A)	C OUTCOM
CHFLUX	LESS THAN ZERO VALUE IMPLIES PRESENCE OF CHAR ELEMENTS IN SURFACE CHEMISTRY	L EQUIL
CIJ(K,KK)	GRAM ATOM OF ELEMENT K IN BASE SPECIES KK.	E EOPCOM
CK1(K)	CALCULATED IN ICOEFF (05B,08A,12B,13B)	C COECON
CK2(K)	SET TO 0 (08A,12B,13B)	C COECON
CK3(K)	DEFINED IN ICOEFF (08A)	C COECON
CK4(K)	DEFINED IN ICOEFF (08A)	C COECON
CK5(K)	SET TO 0 (08A,12B,13B)	C COECON
CK6(K)	NORMALIZED ELEMENTAL MASS FLUX CALCULATED IN ICOEFF (05B,08A,19A,19T)	C COECON
CK9(K)	DEFINED IN ICOEFF (08A,12B)	C COECON
CK11(K)	DRHOK(K) (19T)	C COECON
CK13(K)	DEFINED IN ICOEFF (08A,12B)	C COECON
CK14(K)	SET TO 0 (08A,12B)	C COECON
CK15(K)	SET TO 0 (08A,12B)	C COECON
CK16(K)	SET TO 0 (08A,13B)	C COECON
CK17(K)	DEFINED IN ICOEFF (08A,12B,13B)	C COECON
CK18(K)	DEFINED IN ICOEFF (08A,12B,13B)	C COECON
CK19(K)	DEFINED IN ICOEFF (08A,12B,13B)	C COECON

CK20(K)	SET TO 0 (08A,128)	C COECON
CK21(K)	DEFINED IN ICoeff (08A,128,12C)	C COECON
CK22(K)	DEFINED IN ICoeff (08A,128,138)	C COECON
CK23(K)	$DSQ(I=1) * DPHIKH(K) / 3.$	L IONLY
CK24(K)	$C7 * F(3,I) * CK23(K)$	L IONLY
CK25(K)	$DETA(I=1) * DPHIKH(K)$	L IONLY
CK26(K)	$C7 * F(2,I) * CK25(K)$	L IONLY
CKK1(K,KK)	DEFINED IN ICoeff (08A,128,138)	C COECON
CKK2(K,KK)	DEFINED IN ICoeff (08A,128,138)	C COECON
CKK3(K,KK)	DEFINED IN ICoeff (08A,128)	C COECON
CL	L(I) IN MIXING LENGTH FORMULATION. (19A)	C EPSCOM
CLNUM	CLAUSER NUMBER USED IN DEFINING EDDY VISCOSITY IN THE WAKE PORTION OF THE BOUNDARY LAYER. (07B,19A)	C EPSCOM
CM(K)	ELEMENTAL MASS TRANSFER COEFFICIENTS BASED ON MASS FRACTION POTENTIAL, GIVEN BY $VJKW(K)/(DUM(K)*WAT(K))$ WHERE DUM(K) IS THE SUMMATION OVER KK OF $(SP(1,NETA,KK) -$ $SP(1,1,KK))/WTM(KK)*CIJ(K,KK)$	L OUTPUT
CMF	THE FACTOR BY WHICH ALL CORRECTIONS ARE DAMPED DURING CHEMISTRY ITERATIONS.	L CRECT
CMFF(J)	THE VALUE OF CMF AFTER CONSIDERATION OF CONSTRAINTS ON THE CORRECTION TO BE APPLIED TO THE PARTIAL PRESSURE OF THE JTH SPECIES.	L CRECT
COEEGV(N)	GLOBAL SET OF COEFFICIENTS C5,C6,C7, ETC.	E COECON
COEFOV(N)	GLOBAL SET OF COEFFICIENTS CK1,CK2, ETC.	E COECON
COND	THERMAL CONDUCTIVITY	L OUTPUT
CONE	CONE HALF-ANGLE FOR SPHERE-CONE SHAPED BODIES. (09A)	C PRMCOM
CONJ	25036.5 (778*32,2)	L NONCER
CONEOV	VARIABLE EQUIVALENCED TO COECON FOR DUMPING PURPOSES	L DUMCOM
CORAR(N)	CORRECTION ARRAY, COMPOSED OF CORRECTIONS IN H(I), I=1 TO NETA, AND $(SP(1,1,K), I=1,NETA), K=1,NSPM1.$	E NONCOM
CORMA	THE VALUE OF THE MAXIMUM CORAR. (05B)	C BUMCOM

COSOR	USED IN TRANSVERSE CURVATURE CALCULATION	L OUTPUT
CP(J)	SPECIFIC HEAT, (20A,21A,22A,25A)	C ENTCON
CPA	LOCALLY DEFINED VARIABLE	L MATER
CPBAR(I)	FROZEN SPECIFIC HEAT OF THE MIXTURE, (08A,11A,14A,19A,25A)	C PRPCOM
CPF	FROZEN SPECIFIC HEAT, IDENTICAL TO CCPF+. (20A,22A)	C ENTCON
CPG	FROZEN SPECIFIC HEAT OF GAS, IDENTICAL TO CCPG+. (22A)	C ENTCON
CPTIL	PROPERTY OF THE GAS MIXTURE WHICH REDUCES TO CPBAR FOR EQUAL DIFFUSION COEFFICIENTS, SEE EQ(14) (08A,14A,25A)	C PRPCOM
CRBEQV	VARIABLE EQUIVALENCED TO CRBCOM FOR DUMPING PURPOSES	L DUMCOM
CRHO(I-1)	$C26 * \Delta T(I-1) * (1, -(RHO(I)/RHO(I)) * \Delta T(I-1)/6)$ (11A,12B,13B)	C PRPCOM
CRHO1	$(RHO(L) / RHO(I)) * \Delta T(I-1) * (1, +\Delta T(I-1) * RHO(I) /$ $(RHO(I) * 6.))$	L IONLY
CS(MS)	ENTROPY CORRESPONDING TO SF(MS) (05B,07A)	C EDGCOM
CSPR(MS)	ENTROPY DERIVATIVE WITH RESPECT TO SF(MS) (05B,07A)	C EDGCOM
CSP	EQUILIBRIUM SPECIFIC HEAT OF GAS.	L EQUIL
CT	COEFFICIENT APPEARING IN THE APPROXIMATION FOR THERMAL DIFFUSION COEFFICIENTS, SEE EQ(15). (NUMERICALLY EQUAL TO =0.5) SET EQUAL TO ZERO WHEN THERMAL DIFFUSION NEGLECTED. (08A,14A,25A)	C PRPCOM
CTR	$CT * \text{UNIVERSAL GAS CONSTANT.}$ (08A,14A,25A)	C PRPCOM
CXM	LOCALLY DEFINED VARIABLE	L IONLY
CYM	LOCALLY DEFINED VARIABLE	L IONLY
CYSP	LOCALLY DEFINED VARIABLE	L IONLY
D	SET OF CONSTANT VECTORS CONVERTED TO SOLUTION VECTORS	L RERAY
D	ARGUMENT REPRESENTING DELTA ETA	L TAYLOR
D1	DEFINED BY EQ (3) OR (4)	L HISTXI
D2	DEFINED BY EQ (3) OR (4)	L HISTXI
D2UEDG	SECOND DERIVATIVE OF UEDGE WITH RESPECT TO STREAM FUNCTION, SEE EQ(16) SET EQUAL TO ZERO IN PRESENT PROGRAM.	C EDGCOM
DBAR	REFERENCE DIFFUSION COEFFICIENT INTRODUCED IN APPROXIMATION FOR UNEQUAL DIFFUSION COEFFICIENTS, NUMERICALLY EQUAL TO	L PROPS

	$4.16E-8 * T * \text{SQRT}(T) / (\text{OMEGA} * P),$	
DCAPCH	DERIVATIVE OF CAPC WITH RESPECT TO H, (08A,14A,19A,25A)	C PRPCOM
DCAPCH	DCAPCH AT THE WALL	L TRMBL
DCAPCK(K)	DERIVATIVE OF CAPC WITH RESPECT TO MASS FRACTION OF ELEMENT K (08A,19A,25A)	C PRPCOM
DCLL	DERIVATIVE OF CL AT I WITH RESPECT TO CL AT I-1	L TRMBL
DCLPI	DERIVATIVE OF CL AT I WITH RESPECT TO PI AT I	L TRMBL
DCLPM	DERIVATIVE OF CL AT I WITH RESPECT TO PIM AT I-1	L TRMBL
DCPBH	DERIVATIVE OF CPBAR WITH RESPECT TO H, SET EQUAL TO ZERO IN CURRENT PROGRAM, (14A,25A)	C PRPCOM
DCPBK(K)	DERIVATIVE OF CPBAR WITH RESPECT TO MASS FRACTION OF ELEMENT K. SET EQUAL TO ZERO IN CURRENT PROGRAM, (25A)	C PRPCOM
DCPTH	DERIVATIVE OF CPTIL WITH RESPECT TO H, SET EQUAL TO ZERO IN CURRENT PROGRAM, (14A,25A)	C PRPCOM
DCPTK(K)	DERIVATIVE OF CPTIL WITH RESPECT TO MASS FRACTION OF ELEMENT K. SET EQUAL TO ZERO IN CURRENT PROGRAM, (25A)	C PRPCOM
DCU(I)	(DETA(I))**3 (06A,27A)	C ETACOM
DEL	=VMUE(IS)*C3, LENGTH PARAMETER USED TO NORMALIZE THE Y DIMENSION	L TRMB2
DELJW(K)	ERROR IN DIFFUSIVE MASS FLUX, WALLJ(K), INTRODUCED DURING NEWTON-RAPHSON ITERATION,	C FLXCOM
DELQJW(N)	GLOBAL SET DELQW AND DELJW(K).	E FLXCOM
DELQW	ERROR IN DIFFUSIVE HEAT FLUX, WALLQ, INTRODUCED DURING NEWTON-RAPHSON ITERATION (05B)	C FLXCOM
DELB0	BODY DISPLACEMENT GIVEN BY Y(NETA)=C89/ALPH*F(1,NETA), STORED IN TIME(N),N=11,50 (11A,11B)	L
DELST	DISPLACEMENT THICKNESS GIVEN BY Y(NETA)=C89*(F(1,NETA) -F(1,1))/ALPH, (11A)	C OUTCOM
DELTA	BOUNDARY LAYER THICKNESS PARAMETER USED IN BUSHNELL TURB- ULENT MODEL	L TRMBL
DEPC	CONSTANT IN CORRECTION COEFFICIENTS ON EPSA(I) RESULTING FROM LINEAR CORRECTION COEFFICIENTS (19A)	C EPSCOM
DER(L)	DIMENSIONED VARIABLE USED IN VARIOUS SUBROUTINES BUT NOT	C TEMCOM

USED FOR TRANSMITTING INFORMATION BETWEEN SUBROUTINES.
(07A,11A,19T)

DETA(I)	ETA(I+1) = ETA(I) (06A,10A,12B,13B,18A,19A,19T,27A,29A,50F)	C ETACOM
DF	THRUST LOSS, DEFINED IN B11A	L OUTPUT
DHTILH	DERIVATIVE OF HTIL WITH RESPECT TO H. (08A,14A,25A)	C PRPCOM
DHTILK(K)	DERIVATIVE OF HTIL WITH RESPECT TO MASS FRACTION OF ELEMENT K. (08A,25A)	C PRPCOM
DIV	ROW NORMALIZING FACTOR IN GAUSSIAN ELIMINATION.	L RERAY
DIVC	PRODUCT OF 'DIV' AND ELEMENT OF ROW.	L RERAY
DKPT(MK)	DERIVATIVE OF LOG KP WITH RESPECT TO LOG TEMPERATURE. (28A)	C KINCOM
DLPH	A(3,1) EVALUATED AT THE WALL. (05B)	C NONCOM
DLPK(K)	A(3,K+2) EVALUATED AT THE WALL. (05B)	C NONCOM
DLX1	ALOG(XI(L) / XI(L-1))	L HISTXI
DLX2	STORED (HISTORIC) VALUE FOR DLOGXI DEFINED BY EQ(17) (10A)	C HISCOM
DMU3H	DERIVATIVE OF VMU3 WITH RESPECT TO H. (08A,14A,25A)	C PRPCOM
DMU3K(K)	DERIVATIVE OF VMU3 WITH RESPECT TO MASS FRACTION OF ELEMENT K. (08A,25A)	C PRPCOM
DMU4H	DERIVATIVE WITH RESPECT TO H OF THE COEFFICIENT MU4 DEFINED IN EQ(18) (08A,14A,25A)	C PRPCOM
DMU4K(K)	DERIVATIVE WITH RESPECT TO MASS FRACTION OF ELEMENT K OF THE COEFFICIENT MU4 DEFINED IN EQ(19) (08A,25A)	C PRPCOM
DMU12H	DERIVATIVE OF VMU12 WITH RESPECT TO H, SET EQUAL TO ZERO IN CURRENT PROGRAM. (14A,25A)	C PRPCOM
DMU12K(K)	DERIVATIVE OF VMU12 WITH RESPECT TO MASS FRACTION OF ELE- MENT K, SET EQUAL TO ZERO IN PRESENT PROGRAM. (25A)	C PRPCOM
DPDX(N)	DEFINED IN INPUT INSTRUCTIONS FOR \$INPUT	L GEOM
DPHIKH(K)	DERIVATIVE OF PHIK WITH RESPECT TO H, SET EQUAL TO ZERO IN CURRENT PROGRAM. (08A,13B,25A)	C PRPCOM
DPHIKK(K,KK)	DERIVATIVE OF K TH PHIK WITH RESPECT TO MASS FRACTION OF ELEMENT KK, SET EQUAL TO ZERO IN CURRENT PROGRAM.	C PRPCOM

	(08A,138,25A)	
DPI(3+K,2)	(ARRAY OF DERIVATIVES OF PI WITH RESPECT TO PRIMARY VARIABLES)/TREF (19A)	C EPSCOM
DPRH	DERIVATIVE OF PR WITH RESPECT TO H, SET EQUAL TO ZERO IN CURRENT PROGRAM. (08A,14A,25A)	C PRPCOM
DPRK(K)	DERIVATIVE OF PR WITH RESPECT TO MASS FRACTION OF ELEMENT K. SET EQUAL TO ZERO IN CURRENT PROGRAM. (08A,25A)	C PRPCOM
DQJNL(N)	GLOBAL SET OF DQNL AND DJNL(K).	E FLXCOM
DQJRNL(N)	DERIVATIVE OF DIFFUSIVE HEAT AND MASS FLUXES, WALLQJ WITH RESPECT TO NTH REDUCED NONLINEAR VARIABLE.	E NONCOM
DQRH	DERIVATIVE OF QR WITH RESPECT TO H, SET EQUAL TO ZERO IN CURRENT PROGRAM. (08A,14A,25A)	C PRPCOM
DQRK(K)	DERIVATIVE OF QR WITH RESPECT TO MASS FRACTION OF ELEMENT K. SET EQUAL TO ZERO IN CURRENT PROGRAM. (08A,25A)	C PRPCOM
DRHOH	DERIVATIVE OF RHO WITH RESPECT TO H. (05B,08A,14A,19A,19T,25A)	C PRPCOM
DRHOI	DERIVATIVE OF VELOCITY DEPECT THICKNESS WITH RESPECT TO RHO AT I	L TRMBL
DRHOK(K)	DERIVATIVE OF RHO WITH RESPECT TO MASS FRACTION OF ELEMENT K. (05B,08A,19A,19T,25A)	C PRPCOM
DRHOW	DRHOH AT THE WALL	L TRMBL
DRNL(N)	REDUCED NONLINEAR ERRORS BEFORE MATRIX INVERSION, CORRECTIONS OF VARIABLES IN REDUCED NONLINEAR SET AFTER MATRIX INVERSION. (05B,05C)	C ERRCOM
DSCH	DERIVATIVE OF SC WITH RESPECT TO H, SET EQUAL TO ZERO IN CURRENT PROGRAM. (08A,25A)	C PRPCOM
DSCK(K)	DERIVATIVE OF SC WITH RESPECT TO MASS FRACTION OF ELEMENT K. SET EQUAL TO ZERO IN CURRENT PROGRAM. (08A,25A)	C PRPCOM
DSIP(L)	DECREASE IN ENTROPY FROM PREVIOUS STATION TO CURRENT STATION L AT BOUNDARY LAYER EDGE DUE TO SHOCK CURVATURE (DSIP(1) = 0 BY DEFINITION). (07A,14A,20A)	C EDGCOM
DSQ(1)	(NETA(I))*2 (06A,27A)	C ETACOM
OSTURB	2*STURB	L TRMBL
DSV	LOCALLY DEFINED VARIABLE	L MATS1

DTD	DOWNWARD TEMPERATURE STEP USED IN SEEKING SURFACE EQUILIBRIUM SOLUTION.	L EQUIL
OTEMP	PREDICTED CHANGE IN SURFACE TEMPERATURE FOR THE CURRENT ITERATION DURING A KR(9) = 6 PROBLEM. *NOT USED IN BLIMPJ*	L NONCOM
DTH	DERIVATIVE OF T WITH RESPECT TO H. (05B,08A,14A,25A)	C PRPCOM
DTHW	DTH EVALUATED AT THE WALL. (05B,05C)	C NONCOM
DTK(K)	DERIVATIVE OF T WITH RESPECT TO MASS FRACTION OF ELEMENT K (05B,08A,25A)	C PRPCOM
DTKW(K)	DTK EVALUATED AT THE WALL. (05B,05C)	C NONCOM
DTM	LIMIT VALUE OF DELTA (1./T) IN CHEMISTRY SOLUTION.	L CRECT
DTU	UPWARD TEMPERATURE STEP USED IN SEEKING SURFACE EQUILIBRIUM SOLUTION.	L EQUIL
DUB2	- LOCALLY INPUT VARIABLES, IF NON-ZERO ASSIGNED TO FITMOL, BASMOL, SIGMA AND EPOVRK, RESPECTIVELY -	L INPUT
DUB3		L INPUT
DUB4		L INPUT
DUB5		L INPUT
DUD3(L)	DERIVATIVE OF EDGE VELOCITY WITH RESPECT TO S IN REFCOM, TEMPORARY STORAGE AREA IN OTHER ROUTINES. (07A,11A)	C TEMCOM
DUDX(N)	DEFINED IN INPUT INSTRUCTIONS FOR SINUT	L GEOM
DUEDGE	DERIVATIVE UEDGE WITH RESPECT TO STREAM FUNCTION, SEE EQ (20). (SET EQUAL TO ZERO IN PRESENT PROGRAM). (05B,06A)	C EDGCOM
DUES	DERIVATIVE OF EDGE VELOCITY WITH RESPECT TO STREAMWISE COORDINATE S. (05B,07A)	C EDGCOM
DUM	LOCALLY DEFINED VARIABLE (VARIOUS ROUTINES) (09B)	L
DUM1	LOCALLY DEFINED VARIABLE (VARIOUS ROUTINES)	L
DUM2	LOCALLY DEFINED VARIABLE (VARIOUS ROUTINES)	L
DUM3	LOCALLY DEFINED VARIABLE (VARIOUS ROUTINES)	L
DUM4	LOCALLY DEFINED VARIABLE (VARIOUS ROUTINES)	L
DUM5	LOCALLY DEFINED VARIABLE (VARIOUS ROUTINES)	L
DUM6	LOCALLY DEFINED VARIABLE (VARIOUS ROUTINES)	L
DUM7	LOCALLY DEFINED VARIABLE (VARIOUS ROUTINES)	L
DUM8	LOCALLY DEFINED VARIABLE (VARIOUS ROUTINES)	L
DUMP	P * 10**7, LIMIT PRESSURE IN CONTROLLING DAMPING OF CHEM- ISTRY SOLUTION.	L CRECT

DUZ	LOCALLY DEFINED VARIABLE	L OUTPUT
DVNL(N)	DAMPED NONLINEAR CORRECTIONS, GIVEN BY EQ(21) (05B)	C NONCOM
DVS	VELOCITY DEFECT THICKNESS OVER DEL. (19A)	C EPSCOM
DXDS	DERIVATIVE OF AXIAL COORDINATE WITH RESPECT TO WALL LENGTH COORDINATE. COMPUTED BY LINEAR AVERAGING. (09B)	L GEOM
DY(J)	CORRECTION ON VARIABLE Y(J)* IN CHEMISTRY SOLUTION. (20A,23A)	C EQTCOM
DYI	DAMPED CORRECTION ON VARIABLE Y(J)* IN CHEMISTRY SOLUTION.	L CRECT
DZ	THE D SUB ZERO OF EQ(12)	L HISTXI
DZKH(K)	DERIVATIVE OF ZK WITH RESPECT TO H. (08A,25A)	C PRPCOM
DZKK(K, KK)	DERIVATIVE OF K TH ZK WITH WITH RESPECT TO MASS FRACTION OF ELEMENT KK. (08A,25A)	C PRPCOM
E(N)	ERRORS IN CHEMISTRY EQUATIONS (MASS BALANCE ERRORS FOR N EQUAL TO OR LESS THAN IS*, EQUILIBRIUM ERRORS FOR N GREATER THAN IS*, WHERE IS* IS NUMBER OF ELEMENTS INCLUDING ELECTRON). (20A,22A,23A,28A)	C EQTCOM
EAR	ABSOLUTE VALUE OF EQUILIBRIUM ERROR FOR A SPECIES IN CHEM- ISTRY SOLUTION.	L MATER
EAK(MK)	ACTIVATION ENERGY. (24A,28A)	C KINCOM
EASE	DAMPING FACTOR, APPLIED UNIFORMLY TO ALL CORRECTIONS. (04A,05B,05C,20A,22A,28A)	C BUMCOM
EB(K)	MAGNITUDE OF LARGEST CONTRIBUTION TO K TH MASS BALANCE. (22A,23A,28A)	C EQTCOM
EBL(K)	MINIMUM CONTRIBUTION ACCEPTED TO K TH MASS BALANCE, $\#EB/(10**8)$ (22A)	C EQTCOM
ECD(N)	RESIDUAL ERROR IN CONDENSED EQUILIBRIUM IMPOSED IN CHEMIS- TRY SOLUTION AS A CONSEQUENCE OF BOUNDARY LAYER DAMPING.	L MATER
EDGEQV	VARIABLE EQUIVALENCED TO EDGCOM FOR DUMPING PURPOSES	L DUMCOM
EER	EQUILIBRIUM ERROR OF CONDENSED SPECIES BEING INTRODUCED DURING CURRENT ITERATION.	L MATER
ESE(N)	RESIDUAL ERROR IN MASS BALANCE IMPOSED IN CHEMISTRY SOLU- TION AS A CONSEQUENCE OF BOUNDARY LAYER DAMPING. (28A)	L MATER
EF(N,NN,J)	THERMODYNAMIC CURVE FIT CONSTANTS INPUT IN GROUP 10. (14B)	C EQTCOM

EG2	CONTRIBUTION TO THERMAL FLUX DUE TO INEQUALITY OF TURBULENT PRANDTL AND SCHMIDT NUMBERS	L TTRMBL
EG3	CONTRIBUTION TO THERMAL FLUX DUE TO TURBULENT VISCOUS DISSIPATION	L TTRMBL
EHS	ERROR IN ENTHALPY OR ENTROPY FOR ASSIGNED ENTHALPY OR ENTROPY CHEMISTRY SOLUTIONS.	L MATER
EL	MAXIMUM EQUILIBRIUM ERROR, IDENTICAL TO EEL+. (20A,22A)	C EQTCOM
EL(I)	MIXING LENGTH NORMALIZED BY DEL. (19A)	C EPSCOM
ELCON	MIXING LENGTH CONSTANT AS IN $L = ELCON * Y$. (07B,19A)	C EPSCOM
ELK	LOG OF EQUILIBRIUM IMBALANCE OF KINETIC REACTION.	L KINET
ELKM	LOG OF NON-EQUILIBRIUM OF KINETIC RELATION	L KINET
ELM(N)	GLOBAL SET OF MAXIMUM VALUES OF ERRORS FOR VARIOUS SETS OF TAYLOR SERIES EXPANSIONS. (06A)	C ERRCOM
ELMM	MAXIMUM VALUE OF ELM(N). (04A,05B,06A)	C ERRCOM
EMIS	SURFACE EMITTANCE OF THE MATERIAL BEING CONSIDERED UNDER $KR(9) = 3, 4, 5$ OR 6 . (05C,11A)	C CRBCOM
EMISC	SURFACE EMITTANCE OF THE MATERIAL BEING CONSIDERED UNDER $KR(9) = 3$ OR 4 . (05B,05C)	C CRBCOM
EMIST	SURFACE EMITTANCE OF THE MATERIAL BEING CONSIDERED UNDER $KR(9) = 5$ OR 6 . (05C,09A)	C CRBCOM
EMIV	SURFACE EMISSIVITY (05B,09A)	C CRBCOM
ENL	MAXIMUM MASS BALANCE ERROR, IDENTICAL TO EENL+. (20A,22A)	C EQTCOM
ENL(N)	GLOBAL SET OF ERRORS FOR LINEARIZED CONSERVATION EQUATIONS AND BOUNDARY CONDITIONS. (05B,05C,12B,13B,19A,30C)	C EPRCOM
ENLM(N)	GLOBAL SET OF MAXIMUM VALUES OF ERRORS FOR THE VARIOUS SETS OF LINEARIZED CONSERVATION EQUATIONS AND BOUNDARY CONDITIONS. (05B)	C ERRCOM
ENLMM	LARGEST VALUE OF ENLM. (04A,05B)	C EPRCOM
ENORM	NORMALIZES ERROR IN ENERGY EQUATION	L NNNCR
EOL	MULTIPLYING FACTOR USED TO SMOOTHLY TRANSFORM KINETIC MASS BALANCE TO EQUIVALENT EQUILIBRIUM EQUATION.	L KINET

EP	ERROR IN OVERALL PRESSURE BALANCE.	L MATER
EPI	LOCALLY DEFINED VARIABLE	L TRMBL
EPQVRK	EPSILON/K, OF REFERENCE SPECIES IN DIFFUSION CALCULATIONS (24A,25A)	C EQTCOM
EPS	KINEMATIC EDDY VISCOSITY	L TRMBL
EPS1	KINEMATIC EDDY VISCOSITY IN WALL REGION (19A)	C EPSCOM
EPS2	KINEMATIC EDDY VISCOSITY IN WAKE REGION	L TRMBL
EPSA(I)	$\text{RHO}(I) \times 2 \times (\text{EDDY VISCOSITY}) / (\text{RHO}(L) \times \text{VMUE}(L))$, (05B,11A,19A)	C EPSCOM
EPSOUT	VARIABLE EQUIVALENCED TO EPSCOM FOR OUTPUT PURPOSES	L TRMBL
EQPEQV	VARIABLE EQUIVALENCED TO EQPCOM FOR DUMPING PURPOSES	L DUMCOM
EQTEQV	VARIABLE EQUIVALENCED TO EQTCOM FOR DUMPING PURPOSES	L DUMCOM
ER	ERROR IN MASS BALANCE RELATION.	L MATER
ERP1	DAWSON FUNCTION OF ARGUMENT AT I	L TRMBL
ERP2	DAWSON FUNCTION OF ARGUMENT AT I=1	L TRMBL
ERPP1	DERIVATIVE OF DAWSON FUNCTION WITH RESPECT TO ITS ARGUMENT AT I	L TRMBL
ERPP2	DERIVATIVE OF DAWSON FUNCTION WITH RESPECT TO ITS ARGUMENT AT I=1	L TRMBL
ERREQV	VARIABLE EQUIVALENCED TO ERRCOM FOR DUMPING PURPOSES	L DUMCOM
ET	ERROR TEST FOR BOUNDARY LAYER EQUATIONS.	L ITERAT
ETA(I)	TRANSFORMED COORDINATE IN A DIRECTION NORMAL TO THE SURFACE DEFINED BY EQ (22) (04A,05B,07B,09A,11A,19A,27A,29A,50F,50G)	C ETACOM
ETAQV	VARIABLE EQUIVALENCED TO ETACOM FOR DUMPING PURPOSES	L DUMCOM
ETAT	LOCALLY DEFINED VARIABLE	L FIRSTG
EXEL	RATIO OF FORWARD TO REVERSE DRIVING POTENTIAL IN KINETIC EQUATIONS.	L KINET
EXK(MK)	ALWAYS SET TO 1.0, (REACTION EXPONENT). (24A,28A)	C KINCOM
F2FIX	DESIRED VALUES OF VELOCITY RATIO AT THE NODAL POINTS. (07B,09A,11A,50F)	C RFTCOM
F2FIXT	DESIRED VALUES OF VELOCITY RATIO AT THE NODAL POINTS FOR TURBULENT FLOW. USED ONLY TO CHANGE THE F2FIX AT TRANS- ITION TO TURBULENCE. (07B,09A,11A)	C RFTCOM
F(N,I)	STREAM FUNCTION (N=1), VELOCITY RATIO (N=2) AND DERIVA- TIVES OF ORDER N=2 OF VELOCITY RATIO WITH RESPECT TO ETA, (03A,04A,05B,05C,06A,08A,10A,11A,12B,19A,19T,29A,50A,50G)	C VARCOM

FAMOA(J)	ALPHANUMERIC VARIABLE, FIRST OF TWO PORTIONS OF SPECIES NAME. IDENTICAL TO MOA+. (20A,23A,24A,25A)	C BLOCOM
FAMOB(J)	ALPHANUMERIC VARIABLE, SECOND OF TWO PORTIONS OF SPECIES NAME. IDENTICAL TO MOB+. (20A,23A,24A,25A)	C BLOCOM
FD(N)	$D1 * F(N+1, I) + D2 * HF(I, N+1)$ FOR N=1 THROUGH 3, $D1 * F(4, I-1) + D2 * HF(I-1, 4)$ FOR N=4.	L HISTXI
FEDGE	VALUE OF STREAM FUNCTION AT THE EDGE.	L NNCFER
FF(J)	DIFFUSION FACTOR INTRODUCED BY THE APPROXIMATION FOR DIFFUSION COEFFICIENTS BY EQ(23) (21A,22A,23A,24A,25A)	C EQPCOM
FFA	POWER ON MOLECULAR WEIGHT IF IT IS ASSUMED THAT THE DIFFUSION FACTORS, FF(J), ARE PROPORTIONAL TO SPECIES MOLECULAR WEIGHTS, WTM(J), RAISED TO A POWER. (24A)	C EQPCOM
FFAR	POWER ON MOLECULAR WEIGHT READ IN IF IT IS ASSUMED THAT THE DIFFUSION FACTORS, FF(J), ARE PROPORTIONAL TO SPECIES MOLECULAR WEIGHTS, WTM(J), RAISED TO A POWER OTHER THAN 0.5.	L INPUT
FFF	RATIO OF GAS MOLECULAR WEIGHT TO 'VMU2'. (21A,22A,23A)	L MATER
FFIN(J)	DIFFUSION FACTOR, FF(J), WHICH IS READ IN.	L INPUT
FFK2	PARAMETER SET EQUAL TO WM/VMU2 FOR EQUAL DIFFUSION COEFFICIENTS (KKR(14)=2) AND TO FF(K) FOR UNEQUAL DIFFUSION COEFFICIENT (KKR(14)=0 OR 1).	L PROPS
FITHOL	CONSTANT IN CURVE FIT OF DIFFUSION FACTORS BASED ON MOLECULAR WEIGHTS	L INPUT
FKF(MK)	PRE-EXPONENTIAL FACTOR, POUND MOLES OF REACTANT PER SECOND PER FT**2. (24A,28A)	C KINCOM
FLD(N,NN)	CURVE FIT CONSTANTS FOR THERMODYNAMIC DATA FOR THE FLUID MIXTURE IN KKR(7)=1 OPTION (SIMILAR TO THE QUANTITIES DISCUSSED IN GROUP 13 OF THE INPUT INSTRUCTIONS). NN= 1,2 OR 3 FOR TEMPERATURE RANGES LOW TO HIGH (14B,14C,14D,14E)	C STTCOM
FLE(N)	ERROR FOR THE TAYLOR SERIES EXPANSIONS INVOLVING F(1,I) AND THEIR DERIVATIVES. (05B,06A,30C)	C ERRCOM
FLEM	MAXIMUM VALUE OF FLE(N). (06A)	C ERRCOM
FLIG	FRACTION OF A SPECIES WHICH IS LIQUID. (20A,21A,22A)	C EQTCOM
FLPEQV	VARIABLE EQUIVALENCED TO FLPCOM FOR DUMPING PURPOSES	L DUMCOM
FLUXJ(N,L,1)	CONVERGED VALUE FOR MASS FLUX OF COMPONENT N INTO THE BOUNDARY LAYER AT THE WALL, N = 1 TO 3 FOR EDGE GAS,	C WALCOM

	PYROLYSIS GAS AND CHAR, RESPECTIVELY. (05B,05C,07A)	
FLXEQV	VARIABLE EQUIVALENCED TO FLXCOM FOR DUMPING PURPOSES	L DUMCOM
FM(J)	3 IF UNIMPORTANT SPECIES (NOT SIGNIFICANT IN ANY MASS BALANCE), OTHERWISE 1.	C EQTCOM
FN	LOCALLY DEFINED VARIABLE	L ERP
FNLEM	ERROR FOR THE LINEARIZED MOMENTUM EQUATIONS AND BOUNDARY CONDITIONS. (04A,05B)	C ERRCOM
FNU(K)	VNU(J,K) FOR CURRENT J. (05C,22A)	C EQTCOM
FPPH	F(3,1) PRINTED IN ONE-LINE-PER-ITERATION OUTPUT.	L ITERAT
FR(J,I)	MOLE FRACTION. (11A,20A,25A)	C BLQCOM
FW(L,1)	CONVERGED VALUE OF STREAM FUNCTION AT SURFACE OF BODY. (05C,07A)	C WALCOM
FWCON(L)	INTEGRAND IN CALCULATION OF FW IN REFCOM, TEMPORARY STORAGE AREA IN OTHER ROUTINES. (07A)	C TEMCOM
FWOUM(L)	FW * SQRT(2*XI) IN REFCOM, TEMPORARY STORAGE AREA IN OTHER ROUTINES. (07A,11A)	C TEMCOM
G(N,I)	TOTAL ENTHALPY (N=1) AND ITS DERIVATIVES OF ORDER N=1 WITH RESPECT TO ETA. (05B,05C,06A,08A,10A,11A,12B,19A,24A,29A,50G)	C VARCOM
GAM	ISENTROPIC EXPONENT, DEFINED BY EQ (24).	L EQUIL
GAM1	ISENTROPIC EXPONENT FOR HOMOGENEOUS MIXTURE (14A)	C SITCOM
GAMF(K)	DEFINED BY EQ(25) (05C,20A,22A)	C EQTCOM
GAMH(K)	DEFINED BY EQ(26) (05C,20A,22A)	C EQTCOM
GAMK(K,KK)	DEFINED BY EQ(27)	E NONCOM
GD(N)	D1 * G(N,I) + D2 * HG(I,N) FOR N=1 THROUGH 3, D1 * G(3, I=1) + D2 * HG(I=1,3) FOR N=4.	L HISTXI
GE(M)	STAGNATION ENTHALPY AT BOUNDARY LAYER EDGE. (05B,07A,07B,09A,09B,11A,11B,14A,29A)	C PRMCOM
GEP	DERIVATIVE OF TOTAL ENTHALPY AT BOUNDARY-LAYER EDGE WITH RESPECT TO ETA (05B,06A)	C EDGCOM
GLE(N)	ERROR FOR THE TAYLOR SERIES EXPANSIONS INVOLVING G(1,I) AND THEIR DERIVATIVES. (05B,06A)	C ERRCOM

GLEM	MAXIMUM VALUE OF GLE(N). (06A)	C ERRCOM
GMR	ISENTROPIC EXPONENT FROM EQUILIBRIUM CALCULATION, SEE GAM. (11A,14A,20A)	C PRPCOM
GNLEM	ERROR FOR THE LINEARIZED ENERGY CONSERVATION EQUATIONS. (04A)	C ERRCOM
GRADRO	NOT USED IN BLIMPJ	C PRMCOM
GW	FIRST GUESS FOR WALL ENTHALPY WHICH IS READ IN WHEN KR(2)=0	L FIRSTG
H(I)	STATIC ENTHALPY OF THE MIXTURE, IDENTICAL TO HH*. (05B,08A,11A,14A)	C PRPCOM
H(J)	ENTHALPY, IDENTICAL TO HH*. (20A,21A,22A,25A,28A)	C EQTCOM
HALPH	(10A) STORED (HISTORIC) VALUE OF ALPH ONE STATION UPSTREAM.	C HISCOM
HCARB	HEAT OF FORMATION AT 298 DEG. K OF THE SURFACE MATERIAL BEING CONSIDERED UNDER KR(9) = 3 OR 4. (05B,05C)	C CRBCOM
HCH	CHAMBER (OR STAGNATION) ENTHALPY (20A)	L EQUIL
HCHAR	CHAR ENTHALPY (05B,09A)	C CRBCOM
HE	STATIC ENTHALPY OF GAS AT BOUNDARY-LAYER EDGE. (14A)	C EDGCOM
HEA(L)	STATIC ENTHALPY DISTRIBUTION AT BOUNDARY-LAYER EDGE (05B,07A,20A)	C EDGCOM
HEAT	LOCAL CONTRIBUTION TO THE TOTAL HEAT TO THE WALL	L OUTPUT
HET	TOTAL ENTHALPY OF GAS AT BOUNDARY-LAYER EDGE.	L STATE
HF(I,N)	STORED (HISTORIC) VALUE OF F(N,I) ONE STATION UPSTREAM FOR N=1 THROUGH 4, HF(I,5) = D1*F(1,I) + D2*HF(1,I) WHERE D1 AND D2 ARE DEFINED BY EQ (3) OR(4) (05C,08A,10A,11A,19A)	C HISCOM
HG	ENTHALPY OF GAS, IDENTICAL TO HHG*. (20A,25A)	C EQTCOM
HG(I,N)	STORED (HISTORIC) VALUE OF G(N,I) ONE STATION UPSTREAM. (10A)	C HISCOM
HH(I)	STATIC ENTHALPY OF THE MIXTURE, IDENTICAL TO H*.	C PRPCOM
HH(J)	ENTHALPY, IDENTICAL TO H(J)*. (05B)	C EQTCOM
HINF	FREE-STREAM STATIC ENTHALPY (07A,20A)	C EDGCOM
HIP	ENTHALPY INPUT. (05B,05C,20A,22A)	C EQTCOM

HISEGV	VARIABLE EQUIVALENCED TO HISCOM FOR DUMPING PURPOSES	L DUMCOM
HIST1(N)	SET OF VARIABLES STARTING WITH XI(1) TO BE STORED ON TAPE.	E HISCOM
HIST2(N)	SET OF VARIABLES STARTING WITH PE(1,1) TO BE STORED ON TAPE	E EDGCOM
HIST3(N)	SET OF VARIABLES STARTING WITH F(1,1) TO BE STORED ON TAPE	E VARCOM
HIST4(N)	SET OF VARIABLES STARTING WITH FW(1,1) TO BE STORED ON TAPE	E WALCOM
HM(J)	ENTHALPY OF FUSION.	C EQPCOM
HMAT	HEAT OF FORMATION AT 298 DEG. K OF THE MATERIAL BEING CONSIDERED UNDER KR(9) = 3,4,5, OR 6. (05C)	C CRBCOM
HMELT	HM(J) IF J TH SPECIES IS CHANGING PHASE, OTHERWISE 0. (20A,21A,22A)	C EQTCOM
HOS	ENTHALPY OR ENTROPY OF SPECIES IN ASSIGNED ENTHALPY OR ENTROPY CHEMISTRY SOLUTION.	L MATER
HP	DERIVATIVE OF H WITH RESPECT TO ETA. (05B,08A,19A)	C PRPCOM
HPG	HEAT OF FORMATION AT 298 DEG. K OF THE PYROLYSIS GAS BEING CONSIDERED UNDER KR(9) = 3 OR 4. (05B,05C)	C CRBCOM
HPYG	PYROLYSIS GAS ENTHALPY (05B,09A)	C CRBCOM
HSP(I,N,K)	STORED (HISTORIC) VALUE OF SP(N,I,K) ONE STATION UPSTREAM. (10A)	C HISCOM
HTEF	HEAT OF FORMATION AT 298 DEG. K OF THE MATERIAL BEING CONSIDERED UNDER KR(9) = 5 OR 6. (05C,09A)	CRBCOM
HTIL	PROPERTY OF THE GAS MIXTURE WHICH REDUCES TO H(I) FOR EQUAL DIFFUSION COEFFICIENTS, SEE EQ(28) (08A,14A,25A)	C PRPCOM
HTILP	DERIVATIVE OF HTIL WITH RESPECT TO ETA. (08A)	C PRPCOM
HW(L,1)	CONVERGED ENTHALPY OF GAS AT THE WALL. (05C,07A,25A)	C WALCOM
I	INDEX ON ETA, I=1 AT WALL, IDENTICAL TO II*. (03A,05B,05C,06A,07A,08A,09A,10A,11A,11B,12B,13B,14A,19A, 19T,26A,27A,29A)	L
II	LOCAL INDEX	L KINET
I777	VARIABLE TO CHECK IF SUBROUTINE HAS PREVIOUSLY BEEN ENTERED	C BUMCOM
IAST	ASSIGNED THE VALUE COMMA (,) THROUGH A DATA STATEMENT FOR USE IN TEST OF WHETHER THERE IS TO BE ANOTHER CASE.	L BLIMP
IB(K)	INDEX ON SPECIES WITH LARGEST CONTRIBUTION TO K TH MASS	C EQTCOM

BALANCE, SUBSEQUENTLY ORDERED ON IB WITH DUPLICATES SET
TO 1000.
(22A,23A)

IBLANK	ASSIGNED THE VALUE BLANK () THROUGH A DATA STATEMENT FOR USE IN TEST OF WHETHER THERE IS TO BE ANY PUNCHED CARD OUTPUT.	L OUTPUT
IC(K)	NEGATIVE INDEX OF ELEMENT CORRESPONDING TO KTH BASE SPECIES	L INPUT
ICORM	INDEX CORRESPONDING TO CORMA IN THE CORAR ARRAY. (05B)	C RUMCOM
ICT	CYCLE COUNTER ON POST INVERSION MODIFICATION IN CHEMISTRY SOLUTION	L EQUIL
IDENT	ALPHANUMERIC IDENTIFICATION SYMBOL APPEARING ON PUNCHED CARD DATA (NO CARDS PUNCHED IF IDENT IS INPUT AS A BLANK).	C INTCOM
IDISC(L)	CONTROL VARIABLE FOR DISCONTINUITY (1 IF DISCONTINUITY, OTHERWISE 0). (02A,04A,07A,09A,10A)	C PRMCOM
IDSIP	ITEM WHEN DSIP IS TO BE UPDATED. (07A)	C EDGCOM
IDUM	LOCALLY DEFINED VARIABLE	L SETUP
IE	EQUATION INDEX FOR CONDENSED SPECIES.	L MATER
IENLM	INDICIES ON MAXIMUM NON-LINEAR ERRORS FOR EACH SET OF CONSERVATION EQUATIONS	L RNLCEP
IENLM	INDICIES ON MAXIMUM NON-LINEAR ERRORS FOR EACH SET OF CONSERVATION EQUATIONS	L NONCEP
IER	EQUATION NUMBER TO REPRESENT NEWLY APPEARING CONDENSED SPECIES (20A,23A)	C EQTCOM
IFC(J)	CONTROL FLAG (0 GAS, -1 NONPRESENT CONDENSED, +1 PRESENT CONDENSED, PRIOR FLAGS DECREMENTED BY 3 IF SPECIES CONTAINS NONPRESENT ELEMENT OR INCREMENTED BY 3 IF IT IS A BASE SPECIES REPRESENTING A NONPRESENT ELEMENT). (20A,21A,22A,23A,24A,25A,28A)	C EQPCOM
IFLM	INDEX OF THE SET OF LINEAR EQUATIONS WHICH HAS THE LARGEST ERROR FLEM. (06A)	C ERRCOM
IFLUXJ	ITEM WHEN FLUXJ IS TO BE UPDATED. (07A)	C WALCOM
IFN	INDEX ON LINEAR VARIABLE F(1,I)	L IMONE
IFN	INDEX ON LINEAR VARIABLE F(1,I)	L IONLY
IFNLM	INDEX OF THE LINEARIZED MOMENTUM EQUATION WHICH HAS THE LARGEST ERROR FNLEM. (04A,05B)	C ERRCOM
IFP	INDEX ON NON-LINEAR VARIABLE F(2,I)	L IMONE
IFP	INDEX ON NON-LINEAR VARIABLE F(2,I)	L IONLY

IFPP	INDEX ON LINEAR VARIABLE F(3,I)	L IMONE
IFPP	INDEX ON LINEAR VARIABLE F(3,I)	L IONLY
IFPPP	INDEX ON LINEAR VARIABLE F(4,I)	L IMONE
IFPPP	INDEX ON LINEAR VARIABLE F(4,I)	L IONLY
IFRAC	INPUT FLAG	L STATEN
IFW	ITEM WHEN FW IS TO BE UPDATED. (07A)	C WALCOM
IG	NOMINALLY ZERO, EQUALS ONE ON FIRST SET OF BOUNDARY LAYER CHEMISTRY SOLUTIONS. FIRST GUESS AT I+ IS SOLUTION AT I-IG.	L EQUIL
IG	ELIMINATION INDEX IN BASE SPECIES-ELEMENT CORRESPONDENCE LOGIC.	L INPUT
IGLM	INDEX OF THE SET OF LINEAR EQUATIONS WHICH HAS THE LARGEST ERROR GLEM. (06A)	C ERRCOM
IGNLM	INDEX OF THE LINEARIZED ENERGY CONSERVATION EQUATION WHICH HAS THE LARGEST ERROR GNLEM. (04A)	C ERRCOM
IHW	ITEM WHEN HW IS TO BE UPDATED.	C WALCOM
II	INDEX ON ETA, II=1 AT WALL, IDENTICAL TO I+. (05C,07A,20A,25A)	C INTCOM
IIS	LOCAL INDEX	L RECASE
IJ	LOCAL INDEX	L PROPS
IK	LOCAL INDEX	L PROPS
IL	INDEX ON FIRST CHEMISTRY EQUATION TO BE SOLVED (1 FOR UNKNOWN T AND 2 FOR KNOWN T). (20A,22A)	C EQTCOM
ILEFT	TIMING FLAG, NOT USED IN CURRENT PROGRAM	C INTCOM
ILMM	INDEX OF THE LINEAR EQUATION WHICH HAS THE LARGEST ERROR ELMM. (06A)	C ERRCOM
IM(K)	ROW AND COLUMN INDEX IN INVERSION OF CIJ TO UM. (24A)	L INPUT
IMI	LOCAL INDEX	L INPUT
IMJ	LOCAL INDEX	L INPUT
IML	LOCAL INDEX	L INPUT
IN	NUMBER OF EQUATIONS BEING SOLVED (HAS THE VALUE OF THE LOCAL VARIABLE ISPG IF TEMPERATURE IS UNKNOWN OR ISPG-1 IF TEMPERATURE IS KNOWN). (20A,22A)	C EQTCOM

INLMM	INDEX OF THE NONLINEAR EQUATION WHICH HAS THE LARGEST ERROR ENLMM. (05B)	C ERRCON
INP	IN+2	L CRECT
IP	FLAG FOR PRESSURE INPUT, SEE INPUT DESCRIPTION \$INPUT	L GEOM
IPLOT	FLAG TO OUTPUT PLOT VARIABLES (07A,09A,11A)	C UNICOM
IPRE	ITEM WHEN PRE IS TO BE UPDATED.	C PRMCON
INTEQV	VARIABLE EQUIVALENCED TO INTCON (EXCEPT KR(20)) FOR DIMPING PURPOSES	L DUMCON
INV	FLAG ON RESTART OF CHEMISTRY (PERMITS ONLY ONE RESTART)	L EQUIL
IQ	FOR EACH NON-BASE GASEOUS SPECIES INITIALIZED TO ZERO, SET TO ONE IF SPECIES IS SIGNIFICANT IN ANY MASS BALANCE.	L MATER
IQQ	DEBUG(-2) AND NONCONVERGENT(-1) FLAG ON CALL TO AND RETURN FROM RERAY, RESPECTIVELY.	L EQUIL
IR(K)	CORRESPONDENCE VECTOR BETWEEN BASE SPECIES AND ELEMENTS. (05C,20A,22A,24A)	C EOPCON
IRAD	ITEM WHEN RADR IS TO BE UPDATED. (07A)	C PRMCON
IRE	INDEX ON NEWLY APPEARING CONDENSED SPECIES. (22A,23A)	C EQTCOM
IREO	FLAG FOR ENTROPY LAYER INPUT. *NOT USED IN BLIMPJ*	L REFCOM
IRHOVW	ITEM WHEN RHOVW IS TO BE UPDATED. (07A)	C WALCON
IS	NUMBER OF ELEMENTS INCLUDING ELECTRON, IDENTICAL TO IZ+. (21A,22A,23A,24A,25A,28A)	C EOPCON
IS	INDEX ON S, IS=1 AT STAGNATION POINT OR LEADING EDGE, IDENTICAL TO ISS*. (02A,03A,04A,05B,05C,06A,07A,08A,09A,10A,11A,11B,14A,19A,19T,20A)	C INTCON
ISH	VALUE OF IS AT PREVIOUS STREAMWISE STATION AT WHICH A BOUNDARY-LAYER SOLUTION HAS BEEN OBTAINED (02A,10A)	C INTCON
ISM	NSP=1	L PROPS
ISN	ALPHANUMERIC DATA INPUT ON THERMOCHEMISTRY CARDS (14B,24A)	L
ISP	NUMBER OF ELEMENTS INCLUDING ELECTRON PLUS ONE.	C BUMCON
ISP	SAME AS ISP IN INPUT. (05B,20A,22A)	L EQUI
ISP	(IS*) + 1 WHERE IS* IS THE NUMBER OF ELEMENTS INCLUDING ELECTRONS.	L INPUT

ISP	NSP + 1 (25A)	L PROPS
ISP2	NUMBER OF ELEMENTS INCLUDING ELECTRON PLUS TWO.	C KINCOM
ISP2	NSP + 2 (25A)	L PROPS
ISPLM(K)	INDEX OF THE SET OF LINEAR EQUATIONS WHICH HAS THE LARGEST ERROR SPLEM(K). (06A)	C ERRCOM
ISPN	INDEX ON NON-LINEAR VARIABLE (G(1,I) OR SP(1,I,K))	L IMONE
ISPN	INDEX ON NON-LINEAR VARIABLE (G(1,I) OR SP(1,I,K))	L IONLY
ISPNLM(K)	INDEX OF THE LINEARIZED ELEMENTAL CONSERVATION EQUATION WHICH HAS THE LARGEST ERROR SPNLEM(K). (04A)	C ERRCOM
ISPP	INDEX ON LINEAR VARIABLE (G(2,I) OR SP(2,I,K))	L IMONE
ISPP	INDEX ON LINEAR VARIABLE (G(2,I) OR SP(2,I,K))	L IONLY
ISPPP	INDEX ON LINEAR VARIABLE (G(3,I) OR SP(3,I,K))	L IMONE
ISPPP	INDEX ON LINEAR VARIABLE (G(3,I) OR SP(3,I,K))	L IONLY
ISPO	ISP2 + NUMBER OF PRESENT CONDENSED SPECIES. (20A,22A,23A,28A)	C KINCOM
ISPO	NUMBER OF EQUATIONS SOLVED IN CHEMISTRY SOLUTIONS. IS+2+ NUMBER OF PRESENT CONDENSED SPECIES.	L EQUIL
ISPW	ITEM WHEN SPW IS TO BE UPDATED. (07A)	C WALCOM
ISS	INDEX ON S, ISS=1 AT STAGNATION POINT OR LEADING EDGE. IDENTICAL TO IS+. (20A,25A)	C INTCOM
IST	LOCAL INDEX	L FIRSTG
ISU	INDEX OF SPECIES REPRESENTATIVE OF SURFACE (05B,05C,11A)	C CRBCON
ISV	ISV IS SET EQUAL TO IS* NEAR BEGINNING OF SUBROUTINE PROPS IS* THEN BEING SET TO NSP. IS* RESTORED TO ISV AT THE END OF PROPS.	L PROPS
ISV2	LOCALLY DEFINED VARIABLE	L PROPS
ISVP	ISV+1	L PROPS
IT	NOT USED IN CURRENT VERSION, IDENTICAL TO IIT+. (22A)	C EQTCOM
IT	CURRENTLY SET TO UNITY, IDENTICAL TO IIT*. (02A,03A,05B,05C,06A,07A,09A,11A,14A)	C INTCOM
ITDK	FLAG TO CALL NAMELIST INPUT (07A,09A,11B)	C UNICOM
ITEM	TIME (OR SUBCASE). (02A,03A,05B,07A,11A,14A,20A,29A)	C INTCOM

ITF(11)	FLAG FOR PUNCH CARD OUTPUT, SET TO INPUT VALUE OF KR(8) (09A,11B)	C PRMCOM
ITF(12)	SET EQUAL TO INPUT VALUE OF NTH (09B,11B)	C PRMCOM
ITF(13)	STORES VALUE OF RESTART STATION NUMBER (29A,11A)	C PRMCOM
ITF(14)	STORED VALUE OF INPUT FLAG IP (07A,09B)	C PRMCOM
ITF(15)	STORED VALUE OF INPUT FLAG IU (07A,09B)	C PRMCOM
ITFF	NEGATIVE COUNT ON SUCCEEDING CHEMISTRY SOLUTIONS WHICH WILL ACCEPT RESIDENT SOLUTION AS FIRST GUESS. (20A)	L EQUIL
ITS	COUNTER FOR CHEMISTRY ITERATIONS, IDENTICAL TO IITS+. (20A,21A,22A,28A)	C EQTCOM
ITS	COUNTER FOR BOUNDARY LAYER ITERATIONS, IDENTICAL TO MITS+. (03A,04A,05B,05C)	C INTCOM
ITT	CURRENTLY SET TO UNITY, IDENTICAL TO IT+. (20A,25A)	C INTCOM
ITW	ITEM WHEN TW IS TO BE UPDATED. (07A)	C WALCOM
IU	COUNTER ON NUMBER OF STREAMWISE STATIONS AT WHICH BOUNDARY (02A,05B,09B,10A,20A)	C INTCOM
IU	FLAG FOR EDGE VELOCITY INPUT, SEE INPUT DESCRIPTION SINPUT	L GEOM
IUNIT	FLAG FOR I/O UNITS =0 SI UNITS, =1 ENGLISH UNITS (03A,05B,07A,09A,11A,14A,20A)	C UNICOM
IX	VARIABLE IN RERAY CALL SEQUENCE HAVING TO DO WITH PRINTING OF DEBUG OUTPUT, =2 GIVES DEBUG, COMES BACK 3 IF INVERSION SUCCEEDED, 1 IF SINGULAR. (05B,05C)	C BUMCOM
IX	DIAGNOSTIC FLAG PREVIOUSLY USED TO INDICATE TYPE OF RAD INPUT DETECTED.	L INPUT
IX	DEBUG FLAG.	L RERAY
IZ	NUMBER OF ELEMENTS INCLUDING ELECTRON, IDENTICAL TO IS+. (05B,05C)	C FOPCOM
J	LOCAL INDEX (VARIOUS ROUTINES) (50A,50D)	
JAST	READ IN AS COMMA (,) OR PERIOD (.) FOR TEST OF WHETHER THERE IS TO BE ANOTHER CASE (SEE INPUT INSTRUCTIONS).	L BLIMP
JAT(N)	ATOMIC NUMBER OF AN ELEMENT WHICH CONTAINS ALPT(N) ATOMS IN A SPECIES. (24A)	L INPUT
JB	LOCAL INDEX	L MATS1

JC	INDEX ON SURFACE CONDENSED SPECIES. (20C,22A)	C EQTCOM
JJ	LOCAL INDEX (VARIOUS ROUTINES) (22A)	L
JL	LOCAL INDEX	L TRMRL
JM	J-1, WHERE 'J' IS BASE SPECIES COUNT.	L INPUT
JRHOVW	SET EQUAL TO UNITY IF RHOVW OR FLUXJ ARE READ IN FOR CURRENT TIME, OTHERWISE ZERO.	L REFCOM
JT	LOCAL INDEX	L EQUIL
JTIME	TIME CHECK FLAG, SET TO ZERO IN CURRENT PROGRAM	C INTCOM
KA(N,NN)	HEADING TITLES FOR OUTPUT OF VARIOUS UNITS (02A,07A,09A,11A,11B,20A)	C UNICOM
KAPPA	INDEX OF THE NODAL POINT AT WHICH THE VELOCITY RATIO IS FIXED. (05B,07B,09A,11A,19A,29A,50F)	C INTCOM
KAPPAT	VALUE OF KAPPA WHEN NUMBER OF NODES IS CHANGED AFTER TRANS- ITION TO TURBULENCE (07B,09A,11A)	C RFTCOM
KAT(K)	ATOMIC NUMBER. (20A,22A,24A,25A)	C EQPCOM
KAUXO	SET TO 1. *NOT USED IN BLIMPJ*	C INTCOM
KEDGE	FLAG TO CALL SLOPL (07A,09A)	C SLPCOM
KIN	NUMBER OF TAPE FROM WHICH DATA IS READ. (02A,07A,07B,09A,09B,14B,19A,24A,29A)	C INTCOM
KINEQV	VARIABLE EQUIVALENCED TO KINCOM FOR DUMPING PURPOSES	L DUMCOM
KIP	CONTROL VARIABLE 0 UNLESS PERFORMING ASSIGNED TEMPERATURE CALCULATION DURING KR(9)=6 ENERGY BALANCE PROBLEMS (SEE DEFINITION OF TFZ). (05B,05C)	C BUMCOM
KK	LOCAL INDEX (VARIOUS ROUTINES)	L
KKR(N)	ARRAY OF INPUT INTEGERS WHICH CONTROL THE VARIOUS OPTIONS OF THE PROGRAM, IDENTICAL TO KR+. (20A,24A,25A)	C INTCOM
KONRFT	FLAG TO CALL REFIT OPTION, 0=NO CALL, 1=CALL IF NECESSARY, 2=HAS BEEN CALLED (03A,07B,09A,11A,29A)	C RFTCOM
KOUT	NUMBER OF TAPE ONTO WHICH DATA IS WRITTEN. (02A,03A,04A,05B,05C,07A,07B,09A,10A,11A,11B,14A,14B,15B, 19A,20A,21A,22A,23A,24A,25A,27A,28A,29A,50G)	C INTCOM
KPCH	UNIT NUMBER FOR PUNCH OUTPUT (STORED IN MSD(1)) (02A,11B)	L

KPHA(N)	PHASE INDEX FOR A SPECIES, 1=GAS, 2=SOLID, 3=LIQUID. (24A)	L INPUT
KPLT	UNIT NUMBER FOR PLOT VARIABLES OUTPUT (STORED IN MSD(2)) (02A,07A,11A)	L
KO(N)	IDENTICAL TO KR(N)* BY TRANSMITTAL THROUGH CALL LISTS OF PROGRAMS EQUIL AND INPUT. ALSO IDENTICAL TO KD(N)*. (02A,03A,04A,05B,05C,06A,07A,09A,11A,14A,18B,19A,19T,20A)	C INTCOM
KR(N)	CONTROL CARD FOR CHEMISTRY CALCULATION (KR(1) = 0 FOR ASSIGNED TEMPERATURE, 1 FOR SURFACE EQUILIBRIUM, 2 FOR ASSIGNED ENTHALPY, KR(2) AND KR(3) ARE 1 IF ELEMENT AND SPECIES DATA ARE TO BE READ IN, OTHERWISE 0. KR(4) IS NOT USED, KR(5) IS 0 IF IT IS NOT A BOUNDARY LAYER EDGE SOLUTION, 1 FOR EXPANSION, 2 FOR STAGNATION, KR(6) IS 0 FOR BOUNDARY LAYER CALCULATION, 2 FOR SURFACE MASS BALANCE, KR(7) CONTROLS DEBUG, IDENTICAL TO KZ(N)*. (20A,21A,22A,23A,24A,25A,28A)	C EQPCOM
KR(N)	ARRAY OF INPUT INTEGERS WHICH CONTROL THE VARIOUS OPTIONS OF THE PROGRAM, IDENTICAL TO KKR*. (03A,04A,05B,05C,07A,07B,09A,10A,11A,14A,19A,19T,26A,27A, 29A)	C INTCOM
KR2	KKR(2) (FIRST GUESS FLAG) PRESERVES VALUE SINCE KKR(2) IS RESET TO ZERO IN SETUP. (20A)	L EQUIL
KR3T	STORED VALUE OF KR(3)	L SETUP
KR9(L)	VALUES OF KR(9) WHEN WALL BOUNDARY CONDITIONS ARE TO BE CHANGED AT DOWNSTREAM STATIONS, CURRENT KR(9) ASSIGNMENT MADE NEAR BEGINNING OF SUBROUTINE NONCER. (05B,07B,09A)	C INTCOM
KR10	USED TO SAVE THE INPUT VALUE OF KR(10) (07B,09A,50E,50F,50G,50H)	C RFTCOM
KR17	SAVED VALUE FOR KR(17). (03A)	C INTCOM
KS	SURFACE MATERIAL INDEX (FOR EACH STATION) (05B,07B,09A)	C CRBCOM
KTURB	FLAG INDICATING CHANGE IN THE REFIT PARAMETERS AT TURBULENT TRANSITION. (07B,09A,11A,19A)	C RFTCOM
L(N)	INDEX ON COLUMNS DURING INVERSION.	L RERAY
L2	INDEX ON PYROLYSIS GAS COMPONENT (05B,05C,20A)	C EQTCOM
L3	INDEX ON CHAR COMPONENT (05B,05C,20A,21A)	C EQTCOM
LAM(K,J)	UNITY IF J TH SPECIES CONTAINS K TH ELEMENT, OTHERWISE ZERO	C EQPCOM
LAR(N)	INDEX USED FOR REARRANGING ELEMENTS IN MATRIX OF NONLINEAR EQUATIONS (AM). (05B,05C,27A)	C ETACOM
LAST	ASSIGNED THE VALUE PERIOD (.) THROUGH A DATA STATEMENT FOR USE IN TEST OF WHETHER THERE IS TO BE ANOTHER CASE.	L BLIMP

LEF(K)	FLAG REGARDING MISSING ELEMENTS FOR CURRENT SOLUTION, 3 ALWAYS PRESENT FROM EDGE, 2 ALWAYS PRESENT DUE TO UPSTREAM INJECTION, 1 PRESENT DUE TO LOCAL INJECTION, 0 NOT PRESENT. (03A,05B,05C,20A,29A)	C BLOCOM
LEFS(K)	FLAG REGARDING MISSING ELEMENTS FROM PRIOR SOLUTION, SEE LEF FOR NUMERICAL VALUES, (05B,20A)	C BLOCOM
LEFT(K,N)	TEMPORARY STORAGE FOR LEF(K) DURING TAPE FLIP-FLOP FOR N = 1 AND 2. (03A,20A)	C FLPCOM
LEFUP	UPDATE LEF IF EQUAL TO ZERO (=MITS+II-2 FOR BOUNDARY LAYER SOLUTION, OTHERWISE=1),	L EQUIL
LEFW(K)	FLAG REGARDING MISSING ELEMENTS FOR CURRENT WALL SOLUTION, SEE LEF FOR NUMERICAL VALUES. (05C,20A)	C BLOCOM
LI	LOCAL INDEX	L LINMAT
LIM(K,KK)	LAM(K,KK) FOR KKTH BASE SPECIES. (24A)	L INPUT
LL(MK)	INDEX ON MASS BALANCE WHICH IS CONTROLLED BY N TH KINETIC REACTION. (28A)	C KINCOM
LL(N)	ROW INDEX OF PIVOT FOR NTH COLUMN.	L PERAY
LLL(N)	COLUMN INDEX OF PIVOT FOR NTH ROW.	L PERAY
LNZ	LOCAL INDEX	L RECASE
LPI	LOCAL INDEX (VARIOUS ROUTINES)	
LR	LOCAL INDEX	L TRMBL
LRK	LOCAL INDEX	L TRMBL
LS	INDEX USED TO REARRANGE COLUMNS IN RERAY (SEE LAR)	L RERAY
LSKIP	LOCAL INDEX	L NONCER
M	LOCAL INDEX (VARIOUS ROUTINES) (50H)	
M1	COUNT ON PRINCIPAL SPECIES AFTER ORDERING IB.	L CRECT
MA(MK)	ORDERING VECTOR BASED ON HAVING RAT IN DESCENDING SEQUENCE (28A)	C KINCOM
MAT1I	3 * NETA = 2, NUMBER OF TAYLOR SERIES EXPANSIONS AND LINEAR BOUNDARY CONDITIONS INVOLVING F(1,I) AND ITS DERIVATIVES. (05B,06A,27A,29A)	C INTCOM
MAT1J	NETA + 3, NUMBER OF LINEARIZED MOMENTUM EQUATIONS AND BOUNDARY CONDITIONS. (05B,12B,13B,19A,19T,27A,29A,30C)	C INTCOM
MAT2I	2 * NETA, NUMBER OF TAYLOR SERIES EXPANSIONS AND LINEAR BOUNDARY CONDITIONS INVOLVING G(1,I) AND ITS DERIVATIVES	C INTCOM

OR THE K TH SPECIES, SP(1,I,K), AND ITS DERIVATIVES.
(05B,06A,27A,29A)

MAT2J	NETA, NUMBER OF LINEARIZED ENERGY OR K TH ELEMENTAL CONSER- VATION EQUATIONS AND BOUNDARY CONDITIONS, (05B,12B,13B,19A,19T,27A,29A,30C)	C INTCOM
MD(N)	STORES DATE INFORMATION	C INTCOM
MELT	INDEX ON PHASE CHANGING SPECIES. (20A,21A,22A)	C EQTCOM
MI	MA(K)	L KINET
MIT5	COUNTER FOR BOUNDARY LAYER ITERATIONS, IDENTICAL TO ITS+. (20A)	C INTCOM
MM	LOCAL INDEX (VARIOUS ROUTINES)	
MOA(J)	ALPHANUMERIC VARIABLE, FIRST OF TWO PORTIONS OF SPECIES NAME, IDENTICAL TO FAMOA*. (04A,05B,11A)	C BLOCOM
MOB(J)	ALPHANUMERIC VARIABLE, SECOND OF TWO PORTIONS OF SPECIES NAME, IDENTICAL TO FAMOB*. (04A,05B,11A)	C BLOCOM
MODE	STORED VALUE FOR KR(1)*. (20A,21A,22A)	C EQTCOM
MOE	FLAG SET IN EQUIL AND USED IN CRECT. ZERO RESULTS IN EM- PHASIZING EQUILIBRIUM EQUATIONS DURING CHEMISTRY CONVER- GENCE, ONE RESULTS IN EMPHASIZING MASS BALANCES.	L EQUIL
MP	INDICES USED IN REARRANGING REACTIVE MASS BALANCES ACCORD- ING TO CONTROLLING REACTIONS.	L KINET
MPI	LOCAL INDEX (VARIOUS ROUTINES)	L IMONE
MPJ	LOCAL INDEX (VARIOUS ROUTINES)	L IMONE
MSD(1)	SAME AS KPCH	C PRMCOM
MSD(2)	SAME AS KPLT	C PRMCOM
MSD(N)	*NOT USED IN BLIMPJ* N=3,4,5.	C PRMCOM
MT	NUMBER OF KINETICALLY CONTROLLED REACTIONS. (22A,24A,28A)	C KINCOM
MWE	CONTROL VARIABLE (=1 FOR NEW CASE, SET TO ZERO AT THE END OF SUBROUTINE SETUP). (02A,03A)	C INTCOM
N1	NUMBER OF ROWS + 1	L RERAY
N2I	LOCAL INDEX	L NONCER
N7	ITERATION AT WHICH DIAGNOSTIC OUTPUT WILL COMMENCE	L EQUIL
NAM	NUMBER OF NONLINEAR EQUATIONS NOT INCLUDING NONLINEAR WALL BOUNDARY CONDITIONS, NNLEQ=NRNL. (05B,05C,27A)	C INTCOM

NBT	UNIT NUMBER FOR SCRATCH OUTPUT (02A,03A)	C INTCOM
NBT2	UNIT NUMBER FOR SCRATCH OUTPUT (02A,03A)	C INTCOM
NC	NUMBER OF COMPONENTS OF THE NONREACTING FLUID MIXTURE IN KR(7)=1 OPTION, (148)	C STYCOM
NCV	NONCONVERGENCE COUNT, INITIALLY ZERO, INCREMENTED BY ONE FOR EACH NONCONVERGENT CHEMISTRY SOLUTION. (20A)	L EQUTL
ND	DIMENSION TRANSMITTED THROUGH CALL	L PERAY
NDISC	NUMBER OF DISCONTINUITIES. (07A,09A,19T)	C PRMCOM
NELM	NUMBER OF MAXIMUM LINEAR ERRORS ELM. (06A)	C ERRCOM
NEN	NUMBER OF ENTRIES IN ENTROPY TABLE (05B,07A)	C EDGCOM
NENLM	NUMBER OF MAXIMUM NONLINEAR ERRORS ENLM. (06A)	C ERRCOM
NETA	NUMBER OF NODAL POINTS ACROSS BOUNDARY LAYER INCLUDING WALL AND EDGE.	C INTCOM
NETAT	NEW VALUE OF NETA WHEN NUMBER OF NODES IS CHANGED AFTER TRANSITION TO TURBULENCE (07B,09A,11A)	C RFTCOM
NFF	NUMBER OF SPECIES FOR WHICH DIFFUSION FACTORS, FF(J), ARE TO BE READ IN.	L INPUT
NFIA(J)	FIRST OF TWO PORTIONS OF NAME OF MOLECULE FOR WHICH DIFFU- SION FACTOR, FF(J), IS BEING READ IN. (24A)	L INPUT
NFIB(J)	SECOND OF TWO PORTIONS OF NAME OF MOLECULE FOR WHICH DIFFU- SION FACTOR, FF(J), IS BEING READ IN. (24A)	L INPUT
NFM	NUMBER OF SIGNIFICANT SPECIES PLUS NUMBER OF NONPRESENT ELEMENTS.	L MATER
NITEM	NUMBER OF TIMES (OR SUBCASES). (02A,03A,09A)	C INTCOM
NL	=NSD(5), FLAG FOR USING NAMELIST INPUT \$MISLIS AND \$STALIS (07A,09A,19A,29A)	L
NLEQ	NUMBER OF LINEAR EQUATIONS, MAT1I+NSP*MAT2I. (27A)	C INTCOM
NM	NUMBER OF ROWS LESS ONE	L RERAY
NN	NUMBER BY WHICH COLUMNS EXCEED ROWS IN PRINCIPAL ARRAY	L RERAY
NNLEQ	MAT1J + NSP * MAT2J, TOTAL NUMBER OF NONLINEAR EQUATIONS. (05B,05C,19A,19T,27A)	C INTCOM

NNN	NUMBER OF COLUMN VECTORS IN SECONDARY ARRAY	L RERAY
NON	CONTROL VARIABLE USED AFTER RETURNING FROM SUBROUTINE OUT- PUT (-1 WHEN RERUNNING FROM OUTPUT DURING ITERATIONS, 0 WHEN CONVERGED, +1 WHEN NONCONVERGED AFTER ALLOWED NUMBER OF ITERATIONS). (02A,04A,11A,20A)	C INTCOM
NP	NUMBER OF COLUMNS IN PRIMARY ARRAY.	L RERAY
NP(N)	IDENTIFIES WHICH INPUT STATIONS ARE USED AS SOLUTION STATIONS (09B,11B)	L
NPM1	NPOINT = 1 (07B,09A,50G)	C RFTCOM
NPOINT	NUMBER OF POINTS USED TO DEFINE THE REFIT CURVES (07B,09A,50F,50G)	C RFTCOM
NPR	NUMBER OF DERIVATIVE PROPERTIES TO BE EVALUATED	L PROPS
NRNL	NSP + 1, NUMBER OF REDUCED NONLINEAR EQUATIONS. (05B,05C,27A)	C INTCOM
NS	NUMBER OF STREAMWISE STATIONS. (02A,07A,07B,09A,09B,11A,11B,14A,19T)	C INTCOM
NSD(5)	FLAG FOR USE OF NAMELIST SMISLIS AND SSTALIS (07A,09A,19A,29A)	C PRMCOM
NSP	NUMBER OF ELEMENTS IN THE SYSTEM, NOT INCLUDING ELECTRONS. (05B,05C,06A,07B,09A,11A,20A,25A,27A)	C INTCOM
NSPEC	NUMBER OF SPECIES, IDENTICAL TO N*, (05B,11A)	C BLOCOM
NSPM1	NSP=1 (04A,05B,05C,06A,07A,08A,09A,10A,11A,12B,13B,19A,19T,20A, 25A,27A,29A,50G)	C INTCOM
NTH	DEFINED IN INPUT INSTRUCTIONS \$INPUT, STORED IN ITF(12)	L GEOM
NTIME	CURRENTLY SET TO UNITY. (07A,09A)	C INTCOM
NUL	ZERO.	L HISTXI
OMEGA	PARAMETER OF THIS NAME USED IN TRANSPORT PROPERTY CALCU- LATIONS INTRODUCED IN EQ(29) NUMERICALLY EQUAL TO 1.07/(T/106.7)**0.159	L PROPS
OUTEQV	VARIABLE EQUIVALENCED TO OUTCOM FOR DUMPING PURPOSES	L DUMCOM
P	PRESSURE. (09B,20A,21A,22A,23A,24A,25A,50F,50G)	C EGPCOM
PA(K, KK)	PARTIAL DERIVATIVE OF PROPERTY K WITH RESPECT TO LOG T, LOG AA, LOG(Y(KK-2)).	L PROPS
PE(L, 1)	STATIC PRESSURE. (03A,05B,05C,07A,11A,14A)	C FDGCOM

PHIK(I,K)	SOURCE TERM FOR KTH ELEMENT (EQUAL TO ZERO IN MIXED EQUILIBRIUM-FROZEN BOUNDARY LAYER). (13B,25A)	C PRPCOM
PHIKP(K)	DERIVATIVE OF PHIK WITH RESPECT TO ETA. (08A,13B)	C PRPCOM
PI	P(I) IN MIXING LENGTH FORMULATION. (19A)	C EPSCOM
PID	LOCALLY DEFINED VARIABLE	L TRMBL
PIEASE	PRODUCT OF DAMPING FACTORS. (05B,20A)	C RLOCOM
PIM	P AT NODE I=1	L TRMBL
PIN	P * (10**(5)) USED TO INITIALIZE PARTIAL PRESSURES.	L EQUIL
PIN	SAME AS IN EQUIL.	L WATER
PINF	FREE-STREAM STATIC PRESSURE (07A,20A)	C EDGCOM
PINL	LOG (PIN).	L EQUIL
PITAB(N)	INPUT VALUES OF NORMALIZED EDGE PRESSURE (09B,11B)	L
PKP(MK)	FORWARD RATE OF REACTION. (28A)	C KINCOM
PKR(MK)	REVERSE RATE OF REACTION. (28A)	C KINCOM
PLM	SUMMATION VN(J)*WTM(J) FOR ALL CONDENSED SPECIES.	L EQUIL
PMR(MK)	NET FORWARD RATE OF REACTION. (28A)	C KINCOM
PMU(K,MK)	STOICHIOMETRIC PRODUCT COEFFICIENT ON K TH BASE SPECIES. (24A)	C KINCOM
PMU1	VN(J) * FF(J) SUMMED OVER ALL GASEOUS SPECIES (=VMU1 * P).	L PROPS
PMU2	VN(J) * WTM(J) / FF(J) SUMMED OVER ALL SPECIES N* (=VMU2 * P)	L PROPS
PMU6	VN(J)/(FF(J) * (WD4-VN(J) * FF(J) * WD8)) SUMMED OVER ALL SPECIES N*.	L PROPS
PNUS(K)	SUMMATION VNU(J,K) * VN(J) OVER ALL GASES J. (21A,22A,23A)	L WATER
PR(I)	PRANDTL NUMBER. (08A,11A,14A,25A)	C PRPCOM
PRA	CONSTANT IN THE PRANDTL NUMBER RELATION DEFINING PR (SEE PRDUM). (14A,14B)	C STTCOM
PRB	CONSTANT IN THE PRANDTL NUMBER RELATION DEFINING PR (SEE PRDUM). (14A,14B)	C STTCOM

PRC	CONSTANT IN THE PRANDTL NUMBER RELATION DEFINING PR (SEE PRDUM). (14A,14B)	C STTCOM
PRO	CONSTANT IN THE PRANDTL NUMBER RELATION DEFINING PR (SEE PRDUM). (14A,14B)	C STTCOM
PRDUM	PRANDTL NUMBER IF CONSIDERED CONSTANT, OTHERWISE, IT IS A CONSTANT IN THE RELATION/ $PR=PRDUM+PRA * T ** PRB+PRC*T ** PRD$, USED IN $KR(7)=1$ OPTION ONLY. (14A,14B)	C STTCOM
PRE(L)	RATIO OF LOCAL STATIC PRESSURE TO STAGNATION PRESSURE PTET (07A,09A,14A)	C PRMCOM
PREQ	VARIABLE EQUIVALENCED TO PORTION OF PRPCOM FOR STORAGE TRANSFER	L NONCER
PRF	LOCALLY DEFINED VARIABLE	L TRMBL
PRMEQV	VARIABLE EQUIVALENCED TO PRMCOM FOR DUMPING PURPOSES	L DUMCOM
PRMU(K,MK)	$PMU=RMU$ (28A)	C KINCOM
PRP	LOCALLY DEFINED VARIABLE RELATIVE TO ARRAY OF DERIVATIVE PROPERTIES BEING CALCULATED	L PROPS
PRPEQV	VARIABLE EQUIVALENCED TO PRPCOM FOR DUMPING PURPOSES	L DUMCOM
PRR	ARGUMENT REPRESENTING PRESSURE	L EQUIL
PRT	TURBULENT PRANDTL NUMBER (07B,19A)	C EPSCOM
PTE(L,1)	LOCAL TOTAL PRESSURE. (07A,20A)	C EDGEOM
PTET(1)	STAGNATION PRESSURE. (03A,07A,07B,09A,09B,11A,11B,14A)	C PRMCOM
PTET(2)	NORMALIZING FACTOR FOR PRESSURE, SEE INPUT INSTRUCTIONS (09A)	C PRMCOM
PTET(9)	STORES INPUT VALUE OF RTM, THROAT RADIUS	C PRMCOM
PTET(M)	$M=11,50$. STORES NORMALIZED AXIAL COORDINATE OF THE SOLUTION STATIONS (03A,07A,09B,11A,11B)	C PRMCOM
PV(N,NN)	DERIVATIVES OF $VMU3$ ($NN=1$), $VMU4$ ($NN=2$), $HTIL$ ($NN=3$) AND $ZK(K)$ ($NN=3+K$) WITH RESPECT TO ENTHALPY ($N=1$), PRESSURE ($N=2$) AND K TH ELEMENTAL MASS FRACTION ($N=2+K$).	L PROPS
QA	LOCALLY DEFINED VARIABLE	L SLOPO
QB	LOCALLY DEFINED VARIABLE	L SLOPO
QC	LOCALLY DEFINED VARIABLE	L SLOPO
QOIFU	DEFINED IN $B11A = -K*DT/DY$	L OUTPUT
QI	NUMBER INTRODUCED INTO CALCULATION OF BETAM (WHICH DIFFERS	L REFCOM

FOR VARIOUS BODY SHAPES) DUE TO CHANGE IN MANNER OF INTEGRATION IN THE VICINITY OF THE STAGNATION POINT OR LEADING EDGE.

QR(I)	NET RADIATION FLUX TOWARD THE SURFACE (SET EQUAL TO ZERO IN RLIMP,). (08A,14A)	C PRPCOM
QS	LOCALLY DEFINED VARIABLE	L TRMBL
QW	DIFFUSIVE HEAT FLUX AT THE WALL, C32/C3 EVALUATED AT WALL. (05R)	C FLXCOM
R	LOCALLY DEFINED VARIABLE	L ERP
RA(J,N)	CURVE FIT CONSTANT FOR THERMODYNAMIC DATA (THE QUANTITY A1 DISCUSSED IN GROUP 13 OF INPUT INSTRUCTIONS), N=1, 2, OR 3 FOR LOW TO HIGH TEMPERATURE RANGES, RESPECTIVELY. (21A,24A)	C EQPCOM
RADFL(1)	INCIDENT RADIATION FLUX ABSORBED BY THE SURFACE AT STATION S(1). (07A,07B,09A,11A)	C PRMCOM
RADFL(5)	#UCL FOR AXISYMETRIC FLOW, #1 FOR 2D FLOW (09A,11A)	C PRMCOM
RADFL(6)	#22/7 FOR AXISYMETRIC FLOW, #1/2 FOR 2D FLOW (09A,11A)	C PRMCOM
RADFL(7)	SAVES ROKAP*(NET ENTHALPY FLUX TO WALL)*RADFL(6)/RADFL(5) (11A)	C PRMCOM
RADFL(8)	STORES WALL AREA (11A)	C PRMCOM
RADFL(9)	STORES TOTAL HEAT TO WALL (11A)	C PRMCOM
RADR(L)	RATIO OF INCIDENT RADIATION FLUX ABSORBED BY THE SURFACE TO THE VALUE AT STATION S(1), RADFL. (07A)	C PRMCOM
RADS(L)	INCIDENT RADIATION FLUX ABSORBED BY THE SURFACE. (03A,05C,07A)	C PRMCOM
RAT(MK)	LARGEST OF PKP, PKR, PMR, MEASURE OF REACTION IMPORTANCE. (28A)	C KINCOM
RATLIM	CONSTRAINT USED TO FLAG THE REFIT OPTION. (07B,09A,11A,11B)	C RFTCOM
RB(J,N)	CURVE FIT CONSTANT FOR THERMODYNAMIC DATA (THE QUANTITY A2 (21A,24A)	C EQPCOM
RC(J,N)	CURVE FIT CONSTANT FOR THERMODYNAMIC DATA (THE QUANTITY A3 DISCUSSED IN GROUP 13 OF INPUT INSTRUCTIONS), N=1, 2, OR 3 FOR LOW TO HIGH TEMPERATURE RANGES RESPECTIVELY. (21A,24A)	C EQPCOM
RD(J,N)	CURVE FIT CONSTANT FOR THERMODYNAMIC DATA (THE QUANTITY A4 DISCUSSED IN GROUP 13 OF INPUT INSTRUCTIONS), N=1, 2, OR 3 FOR LOW TO HIGH TEMPERATURE RANGES RESPECTIVELY. (21A,24A)	C EQPCOM

RE(J,N)	CURVE FIT CONSTANT FOR THERMODYNAMIC DATA (THE QUANTITY A5 DISCUSSED IN GROUP 13 OF INPUT INSTRUCTIONS), N=1, 2, OR 3 FOR LOW TO HIGH TEMPERATURE RANGES RESPECTIVELY. (21A,24A)	C EQPCOM
RED	REYNOLDS NUMBER ON DEL WHERE DEL IS THE Y DIMENSION NORMALIZING PARAMETER. ALSO, RED= -VMUE(L)* C3 (19A)	C EPSCOM
REF2	LOCALLY DEFINED VARIABLE	L OUTPUT
REF3	LOCALLY DEFINED VARIABLE	L OUTPUT
REF4	LOCALLY DEFINED VARIABLE	L OUTPUT
REG2	LOCALLY DEFINED VARIABLE	L OUTPUT
REG3	LOCALLY DEFINED VARIABLE	L OUTPUT
RERAD	RADIATION FLUX FROM WALL	L OUTPUT
RES	REYNOLDS NUMBER BASED ON DISTANCE S. (11A)	C OUTCOM
RETA	LOCALLY DEFINED VARIABLE	L OUTPUT
RETHMO	REYNOLDS NUMBER ON MOMENTUM THICKNESS	L OUTPUT
RETR	TRANSITION REYNOLDS NUMBER BASED ON MOMENTUM THICKNESS. (05B,07B,19A)	C EPSCOM
RF(J,N)	CURVE FIT CONSTANT FOR THERMODYNAMIC DATA (THE QUANTITY A6 DISCUSSED IN GROUP 13 OF INPUT INSTRUCTIONS), N=1, 2, OR 3 FOR LOW TO HIGH TEMPERATURE RANGES RESPECTIVELY. (21A,24A)	C EQPCOM
RG(J,N)	CURVE FIT CONSTANT FOR THERMODYNAMIC DATA (THE QUANTITY A7 DISCUSSED IN GROUP 13 OF INPUT INSTRUCTIONS), N=1, 2, OR 3 FOR LOW TO HIGH TEMPERATURE RANGES, RESPECTIVELY. (21A,24A)	C EQPCOM
RHO(I)	DENSITY OF GAS MIXTURE. (08A,11A,14A,19A,19T,25A)	C PRPCOM
RHOE(L)	DENSITY OF BOUNDARY-LAYER EDGE GAS. (05B,07A,08A,11A,14A,19A,19T,25A)	C EDGCOM
RHOINF	FREE-STREAM DENSITY (05B,07A,20A)	C FDGCOM
RHOP(I)	DERIVATIVE OF RHO WITH RESPECT TO ETA. (05B,08A,19A,19T)	C PRPCOM
RHOVS	=RHOVW(L,1)*C3 (05C,19A)	C EPSCOM
RHOVW(L,1)	CONVERGED VALUE FOR SURFACE ABLATION RATE. (05C,07A,11A,25A)	C WALCOM
RHR	DENSITY.	L EQUIL
RI	LOCALLY DEFINED VARIABLE	L TRMBL

RMWG	RATIO OF MOLECULAR WEIGHT OBTAINED BY SUMMING PARTIAL PRESSURES OVER ALL SPECIES TO THE MOLECULAR WEIGHT OBTAINED BY SUMMING OVER GAS PHASE SPECIES ONLY.	C EQTCOM
RMMGS	RMMG*RMWG	L MATER
RMU(K,MK)	STOICHIOMETRIC REACTANT COEFFICIENT ON K TH BASE SPECIES. (24A,28A)	C KINCOM
RNOSE	EFFECTIVE NOSE RADIUS. (07A,09A)	C PRMCOM
RKAP(L)	1 FOR PLANAR BODIES, LOCAL BODY RADIUS FOR AXISYMMETRIC BODIES. (05B,07A,07B,09A,11A,11B,19T)	C PRMCOM
RR	DENSITY RATIO	L TRMBL
RRFD	LOCALLY DEFINED VARIABLE	L TRMBL
RRP	LOCALLY DEFINED VARIABLE	L TRMBL
RRPD	LOCALLY DEFINED VARIABLE	L TRMBL
RSIG(MK)	RELATIVE SIGNIFICANCE OF KINETIC REACTION IN MASS BALANCE. (28A)	C KINCOM
RSQA	RMMGS*FFF/AA	L MATER
RT	PERFECT GAS CONSTANT, R, TIMES TEMPERATURE, T.	L KINET
RTM	THROAT RADIUS, EQUIVALENCED TO PTET(9) (09A,11B)	C PRMCOM
S(L)	STREAMWISE COORDINATE ALONG BODY. (03A,05B,07A,09A,11A,14A,19A,19T)	C PRMCOM
S(N)	LARGEST CONTRIBUTION TO TERM IN N TH COLUMN.	L RERAY
SALPH	SIGNED VALUE OF ALPH	L TRMBL
SB(J)	ENTROPY. (20A,21A,22A)	C EQTCOM
SC(I)	REFERENCE SCHMIDT NUMBER, SEE EQ(30) (08A,11A,14A,25A)	C PRMCOM
SCT	TURBULENT SCHMIDT NUMBER (07B,19A)	C EPSCOM
SD(N)	RATIO OF RESIDUAL TERM IN N TH COLUMN TO S(N).	L RERAY
SDUM1(L)	VARIABLE OF INTEGRATION IN CALCULATION OF XI IN REFCOM, TEMPORARY STORAGE AREA IN OTHER ROUTINES. (07A,19T)	C TEMCOM
SDUM2(L)	VARIABLE OF INTEGRATION IN CALCULATION OF FW IN REFCOM, TEMPORARY STORAGE AREA IN OTHER ROUTINES. (07A,19T)	C TEMCOM
SDY	LOCALLY DEFINED VARIABLE	L TRMBL
SF(MS)	STREAMFUNCTION IN ENTROPY LAYER TABLE (05B,07A)	C FDGCOM

SHAPE	DELST/THMMOM, SHAPE FACTOR.	C OUTCOM
SHEAR	WALL SHEAR GIVEN BY $CAPC(1)/ALPH * VMUE(1S) * UE(1S)/CB9 * F(3,1)/32.1740$ (11A)	C OUTCOM
SHIP	SAVED VALUE OF INPUT ENTHALPY.	L EQUIL
SHMELT	ENTHALPY OR ENTROPY OF FUSION OF A SPECIES IF TEMPERATURE EQUALS FUSION TEMPERATURE OF THAT SPECIES.	L MATER
SIGMA	COLLISION CROSS SECTION FOR REFERENCE SPECIES (24A,25A)	C EQTCOM
SIP	ENTROPY INPUT. (05B,20A,22A)	C EQTCOM
SLAM(K)	DEFINED BY EQ(31) (21A,22A,23A)	C EQTCOM
SM(J)	ENTROPY OF FUSION.	C EQPCOM
SMELT	SM(J) IF J TH SPECIES IS CHANGING PHASE, OTHERWISE 0. (20A,21A,22A)	C EQTCOM
SP(N,I,K)	ELEMENTAL MASS FRACTION (N=1) AND ITS DERIVATIVES OF ORDER N=1 WITH RESPECT TO ETA, (05B,05C,06A,07A,08A,10A,11A,12B,19A,20A,29A,50G)	C VARCOM
SPD(N)	$D1 * SP(N,I,K) * D2 * HSP(I,N,K)$ FOR N=1 THROUGH 3, $D1 * SP(3,I=1,K) * D2 * HSP(I=1,3,K)$ FOR N=4.	L HISTXI
SPDUM(K)	DIMENSIONED VARIABLE USED IN VARIOUS SUBROUTINES BUT NOT USED FOR TRANSMITTING INFORMATION BETWEEN SUBROUTINES.	C TEMCOM
SPE(K,L,1)	ELEMENTAL MASS FRACTION AT BOUNDARY LAYER EDGE, (06A,07A)	C EDGCOM
SPEASE	SAVED VALUE OF PIEASE	L EQUIL
SPLE(N,K)	ERROR FOR THE TAYLOR SERIES EXPANSIONS INVOLVING SP(1,I,K) AND THEIR DERIVATIVES. (05B,06A,30C)	C ERRCOM
SPLM(K)	MAXIMUM VALUE OF SPLE(N,K). (06A)	C ERRCOM
SPNEW	VARIABLE USED TO DENOTE PRESENCE OF NEW ELEMENT IN SYSTEM	L PNLCER
SPNEW	VARIABLE USED TO DENOTE PRESENCE OF NEW ELEMENT IN SYSTEM	L NONCER
SPNLEM(K)	ERROR FOR THE LINEARIZED ELEMENTAL CONSERVATION EQUATIONS. (04A)	C ERRCOM
SPW(K,L,1)	CONVERGED VALUE FOR ELEMENTAL MASS FRACTION OF BOUNDARY LAYER GAS AT THE WALL. (05C,07A,20A,25A)	C WALCOM
SREF	ENTROPY OF REFERENCE STREAMLINE (05B,07A,20A)	C EDGCOM
SS	LOCALLY DEFINED VARIABLE	L SLOPO

SSIP	SAVED VALUE OF INPUT ENTROPY.	L EQUIL
SSTAG	STAGNATION ENTROPY BASED ON 1 ATM PRESSURE.	L STATE
SSTAGA	STAGNATION ENTROPY BASED ON ACTUAL PRESSURE.	L STATE
STEF	STEFAN-BOLTZMANN CONSTANT. (05C,09A)	C CRRCOM
STTEQV	VARIABLE EQUIVALENCED TO STTCOM FOR DUMPING PURPOSES	L DUMCOM
STURB	VALUE OF S AT WHICH TRANSITION TO TURBULENCE OCCURS (05B,19A)	C TURH
SUMD	RT*D LOG KP/D LOG T OF KINETIC REACTION.	L KINET
SUMG	OFF-DIAGONAL COLUMN SUMS OF GAMK USED TO STRENGTHEN DIAGONAL DOMINANCE OF ARRAY.	L EQUIL
SUMK	LOG KP OF KINETIC REACTION.	L KINET
SUML	LOG (SUMN/P) (21A,22A)	C EQTCOM
SUMN	SUMMATION OF PARTIAL PRESSURES FOR ALL GAS PHASE SPECIES. (21A,22A)	C EQTCOM
SUMP	SUM OF PRODUCT Y(N)	L KINET
SUMR	SUM OF REACTANT Y(N)	L KINET
T	STATIC TEMPERATURE IN DEG K, IDENTICAL TO Z+ (20A,21A,22A,23A,25A,28A)	C EQPCOM
T(I)	STATIC TEMPERATURE IN DEG R, IDENTICAL TO TT*. (05B,05C,08A,11A,14A)	C PRPCOM
TAU(K,KK)	INTERMEDIATE ARRAY USED IN FORMING UM.	L INPUT
TAUW	WALL SHEAR	L TRMBL
TC(J)	-D LOG KP / D LOG T FOR FORMATION REACTION OF J TH SPECIES (05B,21A,22A,23A,25A)	C EQTCOM
TCW	TC EVALUATED AT THE WALL FOR THE (ISP)TH ELEMENT. (05B,05C)	C NONCOM
TE(L)	TEMPERATURE AT BOUNDARY LAYER EDGE. (07A,14A)	C EDGCOM
TEMEQV	VARIABLE EQUIVALENCED TO TEMCOM FOR DUMPING PURPOSES	L DUMCOM
TF(J)	FAIL TEMPERATURE OF SPECIES J.	E EQPCOM
TFMAX	MAXIMUM FAIL TEMPERATURE OF CANDIDATE SURFACE SPECIES.	L INPUT
TFO	SURFACE TEMPERATURE TO WHICH CONVERGENCE IS TEMPORARILY ATTEMPTED DURING ENERGY BALANCE PROBLEMS USING KR(9)=6. (05B,05C)	C RUMCOM
THCOND	ENTHALPY THICKNESS	L OUTPUT
THELEM(K)	MASS THICKNESSES GIVEN BY DUZ(K)/DUM(K) WHERE DUZ(K) IS THE SUMMATION OVER KK OF CB9/ALPH * ((F(1,NETA)-F(1,1)) *	L OUTPUT

	SP(1,NETA,KK)=XSP(S,KK))/WTM(KK) * CIJ(K,KK) AND DUM(K) IS THE SUMMATION OVER KK OF (SP(1,NETA,KK)-SP(1,1,KK)/WTM(KK) * CIJ(K,KK).	
THENGY	ENERGY THICKNESS GIVEN BY C89/ALPH * ((F(1,NETA)-F(1,1)) * G(1,NETA)-XG(5))/(G(1,NETA)-G(1,1)) (11A)	C OUTCOM
THMOM	MOMENTUM THICKNESS GIVEN BY C89/ALPH * ((F(1,NETA)-F(1,1)) * XM(5)/ALPH) (11A)	C OUTCOM
TIMD	REAL ELAPSED TIME SINCE BEGINNING OF SOLUTION	L ITERAT
TIME(1)	TIME (OR SUBCASE) (03A,09A,11A,11B)	C PRMCOM
TIME(N)	N=11,50 STORES DELBD (11A,11B)	C PRMCOM
TION	TEMPERATURE BELOW WHICH IONIZATION WILL BE SUPPRESSED	L EQUIL
TITL(N)	TYPE OF AVERAGING EMPLOYED TO CMK(N)	L FELTRU
TJ(N)	SAME AS TR(N) EXCEPT IN DEGREES K (14R)	C EQTCOM
TK(J,N)	MASS (N=1) OR MOLE (N=2) FRACTION OF SPECIES J IN THE MIXTURE (14B)	C EQPCOM
TK(K,N)	GRAM ATOMS OF ELEMENT K PER UNIT MASS OF COMPONENT N. (14B,20A,24A)	C EQPCOM
TM	MAXIMUM OR MINIMUM TEMPERATURE IF DELTA T IS POSITIVE OR NEGATIVE, RESPECTIVELY.	L CRECT
TMAX	MAXIMUM TEMPERATURE ALLOWED FOR CURRENT ITERATION. (20A,21A,22A,23A)	C EQTCOM
TMIN	MINIMUM TEMPERATURE ALLOWED FOR CURRENT ITERATION. (20A,21A,22A,23A)	C EQTCOM
TMU3	VN(J) / FF(J) SUMMED OVER ALL SPECIES N*, (=VMU3*VMUZ*P).	L PROPS
TP	DERIVATIVE OF T WITH RESPECT TO ETA. (05B,08A,19A)	C PRPCOM
TQ(K,N)	GRAM ATOMS OF BASE SPECIES K PER UNIT MASS OF COMPONENT N. SEE W(N) FOR DEFINITION OF COMPONENTS (05C,20A,21A,24A)	C EQPCOM
TR(N)	TEMPERATURE RANGE LIMITS IN DEGREES R (14A,14B)	C STTCOM
TREF	GROUP OF TERMS WHICH APPEARS IN DERIVATIVES OF PI. (REYNOLDS NUMBER ON DELST)/C26/(2.*CAPC(1)**2*YAP**2*PI). (19A)	C EPSCOM
TS	PHASE CHANGE TEMPERATURE.	L INPUT
TT(I)	STATIC TEMPERATURE IN DEG R, IDENTICAL TO T+. (20A,25A)	C PRPCOM

TTMAX	MAXIMUM TEMPERATURE ALLOWED FOR THIS SOLUTION. (20A,21A,22A)	C EGTCON
TTMIN	MINIMUM TEMPERATURE ALLOWED FOR THIS SOLUTION. (20A,21A,22A)	C EGTCON
TTVC	VARIABLE T USED IN TRANSVERSE CURVATURE CALCULATIONS (05B,08A,19A,19T)	C EDGCON
TU(J,N)	UPPER TEMPERATURE OF TEMPERATURE RANGE FOR INPUTTING THERMODYNAMIC PROPERTY DATA FOR SPECIES J, N=1 OR 2 FOR LOWER AND UPPER TEMPERATURE RANGES, RESPECTIVELY. (20A,21A,22A,23A,24A)	C EOPCON
TVCC(19)	CONSTANT USED IN TVC CALCULATIONS (11A,19T)	C EDGCON
TW(L,1)	CONVERGED VALUE OF SURFACE TEMPERATURE. (05C,07A)	C WALCON
TWC(N)	BASE TEMPERATURE USED IN HEAT-TRANSFER-COEFFICIENT CALCULATION	L FELTRU
UCD	UNIT CONVERSION FACTOR TO GET FROM I/O UNITS TO BLIMP UNITS OF DENSITY (02A,07A,09A,11A,11B,14A,20A,29A)	C UNICON
UCE	SEE UCD, FOR ENERGY	C UNICON
UCL	SEE UCD, FOR LENGTH	C UNICON
UCM	SEE UCD, FOR MASS	C UNICON
UCMF	SEE UCD, FOR MASS FLUX/AREA (11A)	L
UCP	SEE UCD, FOR PRESSURE	C UNICON
UCR	SEE UCD, FOR ENERGY FLUX	C UNICON
UCS	SEE UCD, FOR SHEAR	C UNICON
UCT	SEE UCD, FOR TEMPERATURE	C UNICON
UCV	SEE UCD, FOR VISCOSITY	C UNICON
UE(L)	BOUNDARY-LAYER EDGE VELOCITY. (05B,07A,09B,11A,14A,19A,20A)	C EDGCON
UEDGE	SET EQUAL TO UNITY IN PRESENT PROGRAM. (05B)	C EDGCON
UEI(N)	INPUT EDGE VELOCITY, SEE INPUT INSTRUCTIONS SINPOT	L GEOM
UGH	NORMALIZING FACTOR IN GAUSSIAN ELIMINATION.	L INPUT
UINF	FREE-STREAM VELOCITY (05B,07A,20A)	C EDGCON
UKAP	EDGE VELOCITY NORMALIZED BY REFERENCE VELOCITY	L NONCER
UM(K,KK)	MOLECULES OF BASE SPECIES K IN ELEMENT KK. (24A)	L INPUT

(19A)

UNIT(N)	COMPLEX FACTOR HAVING TO DO WITH DAMPING OF KINETICALLY CONTROLLED MASS BALANCES.	C KINCOM
UNIT(N)	SMOOTHING FACTOR RELATED TO IMPOSING RESIDUAL ERROR INTO REACTIVE MASS BALANCES AS A RESULT OF BOUNDARY LAYER DAMPING.	L KINET
UTAU	FRICTION VELOCITY USED IN TURBULENT MODEL FORMULATION	L TRMBL
V	LOCALLY DEFINED VARIABLE	L INPUT
VA	LOCALLY DEFINED VARIABLE (VARIOUS ROUTINES)	L
VAREQV	VARIABLE EQUIVALENCED TO VARCOM FOR DUMPING PURPOSES	L DUMCOM
VB	LOCALLY DEFINED VARIABLE (VARIOUS ROUTINES)	L
VC	LOCALLY DEFINED VARIABLE (VARIOUS ROUTINES)	L
VD	LOCALLY DEFINED VARIABLE (VARIOUS ROUTINES)	L
VE	LOCALLY DEFINED VARIABLE (VARIOUS ROUTINES)	L
VEL	VELOCITY.	L EQUIL
VELSQ	SQUARE OF VELOCITY.	L EQUIL
VINT	$P * 10^{**(-6)}$	L INPUT
VINTR(N)	WAKE CLAMPING FACTORS FOR CEBECI AND KENDALL WAKE LAW	C EPSCOM
VJKW(K)	DIFFUSIVE MASS FLUX OF BASE SPECIES AT THE WALL, $CK6(K)/C3$ EVALUATED AT THE WALL (IN OUTPUT, VJKW(K) IS MODIFIED TO REPRESENT DIFFUSIVE MASS FLUXES OF ELEMENTS AT THE WALL. (05B,11A)	C FLXCOM
VK(K)	$SP(1,I,K)$	L PROPS
VKAP	FLAG FOR BODY SHAPE (0 FOR PLANAR, 1 FOR AXISYMMETRIC). (07A,09A)	C PRMCOM
VK1	LOCALLY DEFINED VARIABLE	L KINET
VK2	LOCALLY DEFINED VARIABLE	L KINET
VK3	LOCALLY DEFINED VARIABLE	L KINET
VLAM	MIXTURE THERMAL CONDUCTIVITY GIVEN BY $RHO(I) * DBAR * VMU6 * 1.9869 / (WM * VMU1)$.	L PROPS
VLAM(J,K)	LAMBDA, DEFINED IN EQ(31) (20A)	E NONCOM
VLNK(J)	LOG KP FOR FORMATION REACTION OF J TH SPECIES (05B,20A,21A,22A)	C EQTCOM
VLNKW	VLNK EVALUATED AT THE WALL FOR THE (ISP)TH ELEMENT. (05B,05C)	C NONCOM
VMACH	MACH NUMBER	L EQUIL
VMACH	MACH NUMBER.	L STATE

VMAT(N)	SET OF VARIABLES STARTING WITH C1 TO BE STORED ON TAPE.	E HISCOM
VMDOYR	TOTAL MASS FLUX IN THE BOUNDARY LAYER, DEFINED IN B11A	L OUTPUT
VMDOYI	MASS FLUX IN THE BOUNDARY LAYER FROM THE INVISCID FLOW	L OUTPUT
VMECH	SURFACE MASS LOSS RATE DUE TO LIQUID LAYER FLOW	L OUTPUT
VMU(I)	VISCOSITY OF MIXTURE, COMPUTED IN SUBROUTINE PROPS AS $\text{RHO}(I) * \text{DBAR} * \text{VMU5}/\text{VMU1}$ (11A,14A,25A)	C PRPCOM
VMU1	COEFFICIENT MU1 DEFINED IN EQ(32)	L PROPS
VMU2	SAME AS VMU2 IN PROPS.	L MATER
VMU2	COEFFICIENT MU2 DEFINED IN EQ(33)	L PROPS
VMU3	PROPERTY OF THE GAS MIXTURE WHICH REDUCES TO 1/MM FOR EQUAL DIFFUSION COEFFICIENTS, SEE EQ(34) (14A,25A)	C PRPCOM
VMU3P	DERIVATIVE OF VMU3 WITH RESPECT TO ETA. (08A)	C PRPCOM
VMU4P	DERIVATIVE OF VMU4 WITH RESPECT TO ETA. (08A)	C PRPCOM
VMU5	CONTRIBUTION TO MIXTURE VISCOSITY GIVEN BY $\text{AMU5} * \text{RMMG}/\text{AA}$.	L PROPS
VMU6	CONTRIBUTION TO MIXTURE THERMAL CONDUCTIVITY GIVEN BY $(\text{PMU6} + \text{CPTIL}/1.9869 - 2.5 * \text{TMU3}) / \text{P}$	L PROPS
VMU12	PRODUCT OF THE TWO COEFFICIENTS VMU1 AND VMU2 (08A,14A,25A)	C PRPCOM
VMUA	CONSTANT IN THE VISCOSITY RELATION $\text{MU}=(\text{VMUA}*T**\text{VMUB})/(\text{VMUC}*T+\text{VMUD})$, USED IN KR(7)=1 OPTION ONLY (14A,14B)	C STTCOM
VMUB	CONSTANT IN THE VISCOSITY RELATION DEFINED UNDER VMUA. (14A,14B)	C STTCOM
VMUC	CONSTANT IN THE VISCOSITY RELATION DEFINED UNDER VMUA. (14A,14B)	C STTCOM
VMUD	CONSTANT IN THE VISCOSITY RELATION DEFINED UNDER VMUA. (14A,14B)	C STTCOM
VMUE(L)	VISCOSITY AT BOUNDARY LAYER EDGE. (05B,07A,11A,14A,19T,25A)	C EDGCOM
VMW(J)	MOLECULAR WEIGHT OF THE SPECIES J (11A,14A,20A,25A)	C PRPCOM
VMWE	MOLECULAR WEIGHT OF GAS AT BOUNDARY LAYER EDGE. (14A,20A,25A)	C EDGCOM
VN(J)	PARTIAL PRESSURE. (20A,21A,22A,23A,24A,25A)	C EQPCOM
VNORM	NORMALIZES ERROR IN MOMENTUM EQUATION	L NNNCER

VNU(J,K)	STOICHIOMETRIC COEFFICIENT ON K TH BASE SPECIES IN FORMATION OF J TH SPECIES. (05C,11A,20A,21A,22A,23A,24A,25A)	C EQPCOM
VVOL	LOCALLY DEFINED VARIABLE	L REFCOM
W(N)	COMPONENT MASS FLUX AT WALL, W(1) IS EDGE GAS, W(2) IS PYROLYSIS GAS, W(3) IS CHAR (03A,05B,05C,11A,20A,23A)	C BLOCOM
WALEGV	VARIABLE EQUIVALENCED TO WALCOM FOR DUMPING PURPOSES	L DUMCOM
WALLJ(K)	NORMALIZED DIFFUSIVE MASS FLUX AT WALL, DEFINED BY EQ(35) (05B,05C,11A,20A)	C FLXCOM
WALLQ	NORMALIZED DIFFUSIVE HEAT FLUX AT THE WALL, DEFINED BY EQ. (36), C32 EVALUATED AT THE WALL (05B,05C,11A)	C FLXCOM
WALLQJ(N)	GLOBAL SET OF WALLQ AND WALLJ.	E FLXCOM
WAT(K)	ATOMIC WEIGHT. (11A,24A)	C EQPCOM
WD2	$1.2 * AISTAR / PMU1$	L PROPS
WD4	$0.284 * WD2$	L PROPS
WD5	$0.32 * AISTAR / PMU1$	L PROPS
WD7	$WD2/PMU1 = WD2$	L PROPS
WD8	$WD4/PMU1 = WD5$	L PROPS
WDOT	ABLATION RATE IN THE CONVERGED SOLUTION OF MATERIAL CONSIDERED UNDER KR(9) = 3 THROUGH 6 (05B,05C)	C BUMCOM
WDZ	CONSTANT 1.385 WHICH ENTERS INTO CALCULATION OF MIXTURE TRANSPORT PROPERTIES.	L PROPS
WM	MOLECULAR WEIGHT OF MIXTURE. (20A,21A,25A)	C EQPCOM
WS	SUM OF PYROLYSIS AND CHAR MASS RATES.	L MATER
WSUM	$W(1) + W(2) + W(3)$	L NONCER
WT	MOLECULAR WEIGHT AS SUMMED.	L INPUT
WTG	PRESSURE * GAS MOLECULAR WEIGHT. (21A,22A,23A,25A)	L MATER
WTL	SUMMATION OF VN(J) * WTM(J) FOR ALL CONDENSED SPECIES. (20A,21A,22A,23A)	L MATER
WTM(J)	MOLECULAR WEIGHT OF SPECIES J. (05B,05C,11A,20A,21A,22A,23A,24A)	C EQPCOM
X(N)	CORRECTIONS OF NONLINEAR VARIABLES IN CHEMISTRY SOLUTION.	E EQTCOM
X1	DAMPED VALUE OF DELTA LN T.	L CRECT
XD	LOCALLY DEFINED VARIABLE	L SLOPO

XG(N)	DEFINED BY EQ(37) EVALUATED FOR $P=G(1,I)$, $N=1$ TO 4, XG(5) IS THE INTEGRAL OF $(F(2,I)*G(1,I)*\Delta T)$ GIVEN BY EQ(38). (11A,12B)	C COECON
XI(L)	TRANSFORMED STREAMWISE COORDINATE DEFINED BY EQ.(39) (07A,10A,11A)	C HISCON
XICON(L)	INTEGRAND IN CALCULATION OF XI IN REFCOM, TEMPORARY STORAGE AREA IN OTHER ROUTINES, (07A)	C TEMCOM
XITAB(N)	INPUT VALUES OF NORMALIZED AXIAL COORDINATE (09B,11B)	L
XJ	LOCALLY DEFINED VARIABLE	L MATS1
XK	LOCALLY DEFINED VARIABLE	L MATS1
XKP	LOCALLY DEFINED VARIABLE	L MATS1
XM(N)	DEFINED BY EQ(40) EVALUATED FOR $P=F(2,I)$, $N=1$ TO 4, XM(5) IS THE INTEGRAL OF $(F(2,I)*F(2,I)*\Delta T)$ GIVEN BY EQ(41) (09B,11A,12B,13B)	C COECON
XOT	LOCALLY DEFINED VARIABLE	L SLOPQ
XOTT	LOCALLY DEFINED VARIABLE	L SLOPQ
XS	LOCALLY DEFINED VARIABLE	L MATS1
XSP(N,K)	DEFINED BY EQ(42) EVALUATED FOR $P=SP(1,I,K)$ $N=1$ TO 4. XSP(5,K) IS THE INTEGRAL OF $(F(2,I)*SP(1,I,K)*\Delta T)$ GIVEN BY EQ(43) (11A,12B,13B)	C COECON
XT	LOCALLY DEFINED VARIABLE	L ABMAX
XTO	LOCALLY DEFINED VARIABLE	L SLOPQ
XTT	LOCALLY DEFINED VARIABLE	L SLOPQ
Y(I)	ACTUAL DISTANCE FROM BODY MEASURED NORMAL TO SURFACE. (11A)	C OUTCOM
Y(J)	NATURAL LOG OF PARTIAL PRESSURE ($\neq 0$ FOR PRESENT CONDENSED SPECIES), IDENTICAL TO $YYY(J)+$ (20A,21A,22A,23A,24A,25A,26A)	C EQPCOM
YAP	CONSTANT IN MIXING LENGTH EQUATION. (07B,19A)	C EPSCOM
YC	INITIAL VALUE OF Y(J)	L INPUT
YDI	LOCALLY DEFINED VARIABLE	L TRMBL
YDIQ	LOCALLY DEFINED VARIABLE	L TRMBL
YDQD	LOCALLY DEFINED VARIABLE	L TRMBL
YDS	LOCALLY DEFINED VARIABLE	L TRMBL
YJNT	ALOG(VINT)	L INPUT

YITAB(N)	INPUT VALUES OF NORMALIZED RADIUS (098,118)	L
YS	LOCALLY DEFINED VARIABLE	L SLOPD
YW(K)	VALUE OF YYY(J) AT WALL (SAVED) (05C,20A,25A)	C EQPCOM
Z	STATIC TEMPERATURE IN DEG K, IDENTICAL TO T*, (09B,11B,20A)	C EQPCOM
ZG(N,I)	DEFINED BY EQ(44), EVALUATED FOR P=G(1,I), N=1 TO 4 (10A,12B)	C HISCOM
ZIGEPS(N)	NOT USED IN BLIMPJ	C EQTCOM
ZK(K)	QUANTITY FOR ELEMENT K WHICH IS INTRODUCED AS A RESULT OF THE APPROXIMATION FOR BINARY DIFFUSION COEFFICIENTS AND REDUCES TO SP(1,I,K) FOR EQUAL DIFFUSION COEFFICIENTS, SEE EQ(45) (08A,25A)	C PRPCOM
ZKP(K)	DERIVATIVE OF ZK WITH RESPECT TO ETA, (08A)	C PRPCOM
ZM(N,I)	DEFINED BY EQ(46), EVALUATED FOR P=F(2,I), N=1 TO 4 (10A,12B,13B)	C HISCOM
ZSP(N,I,K)	DEFINED BY EQ(47), EVALUATED FOR P=SP(1,I,K) N=1 TO 4 (10A,12B,13B)	C HISCOM

SECTION 5

INPUT

A comprehensive set of input instructions comprises the bulk of this section. Within these instructions are discussions of some of the options and helpful suggestions for selection of input. The primary selection of all program options is made in Group 1 through the choice of the KR's. A complete description of the input variables is given in the group-by-group description of the Formatted input in Section 5.2. This section also contains recommended values for many of the input parameters. The units for input and output can be selected as either English Engineering or S.I. (The internal working units of the program are English Engineering except for the chemistry subroutines which use CGS units.) An expanded discussion of code usage and selection of the appropriate options is presented in Section 6.

5.1 CONSECUTIVE CASES

The use of a comma in Group 17 for consecutive cases permits a reduction in input for certain situations. The KR(1), KR(2), and KR(12) flags can be used to eliminate portions of the input data as shown below.

KR(1) = 0,2 Eliminate Group 4

KR(2) = 2 Eliminate Group 9

KR(12) = 1 Eliminate Group 10 or Groups 11, 12, and 13

By far, the most useful of these is the KR(12) = 1 option which can be used for a sequence of problems in which the input chemistry data does not change. Another useful application is for generating a first guess by first getting a solution to a similar, but simpler, problem whose last solution station corresponds to the first solution station of the actual problem. In this case all three KR flags would be useful. An example of this could be for starting a fully turbulent boundary layer with a large upstream length for which the built-in first guess did not yield a successful solution. The simpler problem could consist of several upstream stations, constant pressure, constant wall temperature, similar solutions and the same chemistry deck. The last solution of this relatively simple problem would then provide a first guess for the more difficult problem.

5.2 DESCRIPTION OF INPUT

INPUT AND OUTPUT UNITS FOR BLIMP CAN BE EITHER SI OR ENGLISH ENGINEERING (SEE KR(13)) THE INPUT INSTRUCTIONS ARE WRITTEN FOR SI UNITS. EQUIVALENT ENGLISH UNITS FOR INPUT ARE GIVEN BELOW. NOTE THAT THE THERMOCHEMICAL CURVE FIT DATA AND THE TEMPERATURE RANGES IN GROUPS 10 AND 13 ARE INPUT ONLY IN SI UNITS.

	SI	MULTIPLY BY/TO GET	ENGLISH
ENERGY	J/KG	4.3021E-04	BTU/LBL
ENERGY FLUX	J/S-M2	8.8114E-05	BTU/S-FT2
LENGTH	M	3.28084	FT
MASS FLUX	KG/S-M2	0.204816	LSM/S-FT2
PRESSURE	N/M2	9.86923E-06	ATM.
TEMPERATURE	K	1.8	R

BLIMP-J WILL ACCEPT INPUT IN EITHER FORMATTED OR NAMELIST FORM. THE NAMELIST INPUT IS ACTIVATED BY THE KR(1) AND KR(6) SPECIFICATIONS ON CARD 1 OF GROUP 1. THERE ARE THREE NAMELIST WHICH CAN BE USED. THEY ARE SHOWN BELOW WITH THE GROUPS OF DATA THAT THEY REPLACE:

\$MISLIS - 2, 3, 4, 5, 7, 8, 9.

\$INPUT - PART OF 3, PART OF 5, AND PART OF 15.

\$STALIS - 15, 16.

THE SPECIFIC VARIABLES AND ANY DEFAULT VALUES ARE SHOWN IN THE NAMELIST DESCRIPTION WHICH FOLLOWS. THE VARIABLES THEMSELVES AND THE PLACEMENT OF THE NAMELISTS ARE DESCRIBED IN THE DETAILED INPUT INSTRUCTIONS FOR FORMATTED INPUT

THE DECK SETUP FOR COMPLETE NAMELIST INPUT IS AS FOLLOWS:

```

GROUP 1 (KR(1)=3)
$MISLIS
$INPUT (IF KR(6)= 3,6, OR 7)
GROUP 6 (IF KR(9) OR ANY OF THE KR9(L) .GT. 2)
GROUP 9 (IF KR(2) .NE. 0)
GROUP 10 (IF KR(7)= 1 OR 3)
GROUP 11,12,13 (IF KR(7)= 0 OR 2)
$STALIS

```

*** NAMELIST \$MISLIS ***

WHEN \$MISLIS IS USED GROUPS 2,3,4,5,7,8, AND 9 ARE NOT USED. DESCRIPTIONS OF THE VARIABLES IN \$MISLIS CAN BE FOUND IN THESE GROUPS. BUILT IN DEFAULT VALUES OF THE VARIABLES IN GROUPS 4 AND 8 ARE SHOWN FOLLOWING THE VARIABLES LIST FOR \$MISLIS.

VARIABLES INPUT WITH SMISLIS

NSP,KS = GROUP 2

NS,KRQ,S = GROUP 3

NETA,ETA,KAPPA,CBAR,KONRFT,NPOINT,RATLIM,KTURB,KAPPAT,NETAT,F2FIX,
F2FIXT = GROUP 4

RTM,RDKAP = GROUP 5

PTET(1),PTET(2),GE(1),RADFL(1) = GROUP 7

ELCON,YAP,CLNUM,SCT,PRT,RETR = GROUP 8

GW = GROUP 9 (ONLY FOR KR(2)=0, THIS GROUP NOT PART OF SMISLIS FOR
KR(2) .NE. 0)

DEFAULT VALUES FOR GROUP 4 (ALL OTHER VARIABLES ARE SET TO ZERO.)

CBAR = 0.95

RATLIM = 0.5

NPOINT = 3

FOR (KR(7)=0,1) NETA=7, KAPPA=6

NODE	ETA	F2FIX
1	0.0	0.0
2	0.5	0.2
3	1.0	0.4
4	1.5	0.6
5	2.0	0.8
6	3.0	0.95
7	5.0	1.0

FOR (KR(7)=2,3) NETA=12, KAPPA=10

NODE	ETA	F2FIX
1	0.0	0.0
2	0.002	0.05
3	0.006	0.12
4	0.01	0.25
5	0.025	0.35
6	0.06	0.45
7	0.15	0.6
8	0.4	0.75
9	0.7	0.85
10	1.0	0.95
11	1.5	0.98
12	2.5	1.0

IF IT IS DESIRED TO USE KTURB=1 THE ETA, F2FIX, AND F2FIXT MUST BE READ
IN. THE ABOVE DISTRIBUTION CAN BE USED AS INPUT WITH NETAT=12 AND
KAPPAT=10.

DEFAULT VALUES FOR GROUP 8

ELCON = 0.44

YAP = 11.823

CLNUM = 0.018

SCT = 0.9
PRT = 0.9
RETR = 0.0

*** NAMELIST \$INPUT ***

WHEN \$INPUT IS USED GROUP 3, CARD SET 2, FIELDS 2,3, ETC.; GROUP 5, CARD SET 2; AND GROUP 15, CARD SET 3 ARE NOT USED.

NAMELIST/INPUT/ INCLUDES THE FOLLOWING VARIABLES

N = NUMBER OF INPUT VALUES FOR PITAB, ETC. MAX=500.

NTH = IDENTIFIES THE THROAT VALUES IN THE LIST OF N INPUT VALUES OF PITAB, ETC.

NP(I), I=1, NS = IDENTIFIES THE NS SOLUTION STATIONS FROM THE N INPUT STATIONS. ENTER IN ASCENDING ORDER. A NEGATIVE ENTRY HAS THE SAME EFFECT AS A NEGATIVE ENTRY FOR S(I) DISCUSSED IN CARD SET 2, FIELD 2, GROUP 3.

IP = FLAG FOR TREATMENT OF EDGE PRESSURE

0 PRESSURE GRADIENTS CALCULATED FROM ISENTROPIC EXPANSION VELOCITIES, $DPDS = -DUDS * UE * RHOE$

1 PRESSURE GRADIENTS CALCULATED BY AVERAGING THE STRAIGHT LINE SLOPES TO ADJACENT POINTS OF PITAB(I), I=1, N

2 PRESSURE GRADIENT (DPOX) INPUT IN \$INPUT

IU = FLAG FOR TREATMENT OF EDGE VELOCITY

0 VELOCITY CALCULATED BY ISENTROPIC EXPANSION FROM STAGNATION CONDITIONS. VELOCITY GRADIENT CALCULATED BY CURVE FIT OF THE VELOCITIES AT THE NS SOLUTION STATIONS IF IP=0. IF IP= 1,2 VELOCITY GRADIENTS CALCULATED FROM $DUDS = -DPDS/UE/RHOE$.

1 VELOCITY INPUT IN \$INPUT AS UEI(J), J=1, N. GRADIENTS CALCULATED BY AVERAGING THE STRAIGHT LINE SLOPES TO ADJACENT POINTS.

2 VELOCITY AND VELOCITY GRADIENT (DUOX) INPUT IN \$INPUT.

DPOX, DUOX = DERIVATIVE WITH RESPECT TO XITAB OF PITAB AND UEI.
MAX=500.

UEI = EDGE VELOCITY. MAX=500.

XITAB, YITAB = BODY CONTOUR COORDINATES NORMALIZED BY RTM. (FOR A CIRCULAR CROSS SECTION NOZZLE YITAB IS THE RADIUS/RTM AND RTM=THROAT RADIUS.)

PITAB = PRESSURE AT EACH STATION NORMALIZED BY THE STAGNATION PRESSURE (SEE ALSO GROUP 7, CARD 1, FIELDS 1 AND 2.)

*** NAMELIST \$STALIS ***

WHEN \$STALIS IS USED GROUPS 15 AND 16 ARE NOT USED. DESCRIPTIONS OF THE VARIABLES IN \$STALIS CAN BE FOUND IN THESE GROUPS. ALL VARIABLES NOT INPUT ARE SET TO ZERO. NOTE THAT PRE MAY ALSO BE INPUT IN NAMELIST \$INPUT (\$INPUT IS PREFERRED WHEN USING TDK OUTPUT.)

DSIP(L),PRE(L),RADR(L),L=1,NS = GROUP 15

HW(L,1),TW(L,1),RHOVW(L,1),SPW(K,L,1),FLUXJ(N,L,1),K=1,NSP-1,N=1,3,
L=1,NS = GROUP 16

*** NOTE *** SUBSCRIPTED VARIABLES: LEFT MOST INDEX VARIES FASTEST.

*
***** DESCRIPTION OF FORMATTED INPUT *****
*

CARD GROUP IDENTIFICATION

ALL CARDS WITH THE EXCEPTION OF THE NAMELIST INPUT (GROUP 3) AND THE THERMOCHEMICAL DATA INPUT (GROUP 13) USE COLUMNS 73-80 FOR IDENTIFICATION (THIS IS OPTIONAL)

5 DIGIT NUMBER IN COLUMNS 73-77

FIRST TWO DIGITS (73,74) = GROUP NUMBER

THIRD DIGIT (75) = CARD OR CARD SET NUMBER

LAST TWO DIGITS (76,77) = CARD NUMBER FOR CARDS WITHIN A CARD SET

COLUMN 80 = ALPHABETIC CHARACTER USED FOR CASE IDENTIFICATION

EX. 1) THIRD CARD OF CARD SET 2 IN GROUP 9, CASE A
09203 A

2) CARD 1 OF GROUP 12 (NOT A CARD SET), CASE B
12100 B

GROUP 1 CONTROL CARD, TITLE, AND IDENTIFICATION (CALLED FROM RECASE)

CARD 1,FORMAT(20I1,1SA4),KR

FIELD 1 (COLUMNS 1-20) THIS IS THE VARIABLE KR(DIMENSIONED 20) WHICH IS USED TO CONTROL THE VARIOUS PROGRAM OPTIONS

COLUMN 1 DETERMINES WHETHER A NEW SET OF ETA VALUES IS TO BE INPUT FOR PRESENT CASE (SEE GROUP 4)

0 USES RESIDENT VALUES FROM PREVIOUS CASE

- 1 VALUES INPUT BY USER (MANDATORY FOR FIRST CASE OR FOR RESTART)
- 2 SAME AS 0 EXCEPT NAMELIST SMISLIS AND SSTALIS USED
- 3 SAME AS 1 EXCEPT NAMELIST SMISLIS AND SSTALIS USED

COLUMN 2 DESIGNATES TYPE OF FIRST GUESSES TO BE UTILIZED FOR PRIMARY VARIABLES (SEE GROUP 9)

- 0 USES BUILT-IN RELATIONS TO CALCULATE FIRST GUESSES (REQUIRES READING ONLY GUESS FOR ENTHALPY OF THE GAS AT THE WALL), RECOMMENDED FOR MOST SITUATIONS.
- 1 FIRST GUESSES INPUT BY USER
- 2 USES RESIDENT VALUES FROM PREVIOUS CASE (CANNOT BE USED FOR FIRST CASE OR WHEN COMPOSITION OF EDGE GAS CHANGES)
- 3 FIRST GUESSES INPUT BY USER ARE ACCEPTED AS SOLUTION AT FIRST OR RESTART STATION.

COLUMN 3 DETERMINES TREATMENT OF STREAMWISE DERIVATIVES.

- 0 PERFORMS SIMILAR SOLUTION AT EACH STREAMWISE STATION
- 1 CONSIDERS TWO-POINT DIFFERENCE RELATIONS AT ALL STATIONS WITH THE FOLLOWING EXCEPTION (A SIMILAR SOLUTION IS PERFORMED AT THE FIRST STATION)
- 2 CONSIDERS THREE POINT DIFFERENCE RELATIONS AT ALL STATIONS WITH THE FOLLOWING EXCEPTIONS (A SIMILAR SOLUTION IS PERFORMED AT THE FIRST STATION AND A TWO-POINT SOLUTION IS PERFORMED AT THE SECOND STATION AND A TWO-POINT SOLUTION IS PERFORMED FOR THE FIRST STATION AFTER A DISCONTINUITY OR A REFIT STATION, SEE CARD SET 4 OF GROUP 3)
- 3,4,5 SAME AS 0,1,2 EXCEPT A LINEAR CURVE FIT (SLOPL) IS USED INSTEAD OF A QUADRATIC CURVE FIT (SLOPQ) FOR EDGE CONDITIONS.

COLUMN 4 DETERMINES WHEN OUTPUT BLOCK IS TO BE PRINTED

- 0 OUTPUT BLOCK PRINTED FOR CONVERGED SOLUTION OR FOR NONCONVERGED SOLUTION AFTER 50 ITERATIONS (WITH APPROPRIATE COMMENT)
- 1 OUTPUT BLOCK PRINTED AFTER EACH ITERATION

COLUMN 5 DETERMINES TREATMENT OF ENTROPY LAYER

- 0 FOR MOST ROCKET NOZZLE PROBLEMS
- 5 NON ISENTROPIC EXPANSION, CHANGES IN EDGE ENTROPY INPUT IN GROUP 15. (USE ALSO KR(10)= 2) THIS IS A SPECIAL OPTION THAT CAN BE USED WHEN IT IS DESIRED TO DETERMINE THE EDGE STATE FROM LOCAL PRESSURE AND ENTROPY RATHER THAN ISENTROPIC EXPANSION OR LOCAL PRESSURE AND VELOCITY AS IN KR(5)= 0.

COLUMN 6 DESIGNATES BODY SHAPE

3 PLANAR SHARP - BODY CONTOUR AND PRESSURE DISTRIBUTION INPUT IN NAMELIST FORM (CAN BE USED FOR BOUNDARY LAYER PREDICTIONS ALONG THE WALL OF A RECTANGULAR CROSS SECTION NOZZLE).

4 AXISYMMETRIC NOZZLE

6 AXISYMMETRIC NOZZLE - NOZZLE SHAPE AND PRESSURE DISTRIBUTION IN NAMELIST FORM (EX, TDK OUTPUT) (USED WITH GROUP 3, CARD SET 3)

7 SAME AS 6 WITH TRANSVERSE CURVATURE CONSIDERED.

8 AXISYMMETRIC NOZZLE WITH TRANSVERSE CURVATURE (NOT RECOMMENDED)

*** NOTE *** TRANSVERSE CURVATURE SHOULD BE CONSIDERED ONLY WHEN THE BOUNDARY LAYER THICKNESS IS NOT MUCH LESS THAN THE NOZZLE RADIUS.

COLUMN 7 DESIGNATES WHETHER OR NOT TURBULENT FLOW WILL BE CONSIDERED.

0 LAMINAR FLOW ONLY

1 LAMINAR FLOW ONLY. NONREACTING GAS, USE GROUP 10 INPUT.

2 TURBULENT FLOW WILL BE COMPUTED IF TRANSITION CRITERIA IS EXCEEDED (SEE GROUP 8).

3 SAME AS 2. NONREACTING GAS, USE GROUP 10 INPUT.

COLUMN 8 DESIGNATES WHETHER OR NOT BODY SHAPE CORRECTED FOR DISPLACEMENT THICKNESS WILL BE OUTPUT

0 NO CORRECTED BODY CONTOUR

1 CORRECTED BODY CONTOUR AND PUNCH OF R-CORRECTION. THIS GIVES INVISID FLOW CONTOUR FOR THE GIVEN BODY CONTOUR.

2 CORRECTED BODY CONTOUR AND PUNCH OF R+CORRECTION. THIS GIVES NEW BODY CONTOUR IF PRESENT CONTOUR IS THE DESIRED INVISID CONTOUR.

3 CORRECTED BODY CONTOUR(R+-DELTA STAR) NO PUNCH

*** NOTE *** THROAT AXIAL COORDINATE IS ZERO.

COLUMN 9 TOGETHER WITH COLUMN 11, THIS SPECIFIES THE TYPE OF WALL BOUNDARY CONDITIONS. (SEE SECTION 6)

0 NOT USED.

1 USED FOR KR(7)= 1 OR 3. ASSIGNED TOTAL MASS FLUX AT THE WALL.

2 ASSIGNED COMPONENT MASS FLUXES AT THE WALL (MDOT EDGE GAS, MDOT PYROLYSIS GAS, MDOT CHAR-- REQUIRES KR(11) = 0, 1, OR 2). NOT RECOMMENDED FOR KR(7)= 1 OR 3

3 ASSIGNED WALL TEMPERATURE AND ENERGY BALANCE WITHOUT SURFACE EQUIL.

4 WALL STEADY STATE ENERGY BALANCE WHILE SATISFYING WALL MASS
BALANCES AND LIMITED SURFACE EQUILIBRIUM (USE KR(11) = 0,
KR(7) = 0 OR 2.)

7 ADIABATIC WALL (USE KR(11)=0)

COLUMN 10 DETERMINES TYPE OF CURVE FITS EMPLOYED TO REPRESENT THE
PRIMARY VARIABLES OF VELOCITY RATIO, TOTAL ENTHALPY, AND
ELEMENTAL MASS FRACTIONS (KR(10)=1 IS STRONGLY
RECOMMENDED FOR ACCURACY FOR MOST PROBLEMS,)

0 UTILIZES CONNECTED CUBICS

1 UTILIZES CONNECTED QUADRATICS EXCEPT FOR OUTERMOST SEGMENT WHERE
CONNECTED CUBICS ARE EMPLOYED

2 UTILIZES CONNECTED QUADRATICS EVERYWHERE.

COLUMN 11 TOGETHER WITH COLUMN 9, THIS DESIGNATES THE TYPE OF WALL
BOUNDARY CONDITION SEE GROUP 16.

0 ASSIGNED WALL TEMPERATURE. ALSO USED WITH KR(9)=4. THIS OPTION
TOGETHER WITH KR(9)=2 WILL YIELD SURFACE EQUILIBRIUM
IF THE ASSIGNED TEMPERATURE IS GREATER THAN THE
ASSIGNED ABLATION TEMPERATURE (SEE GROUP 11, CARD 1, FIELD 7).
THE PROGRAM WILL CALCULATE THE APPROPRIATE CHAR FLUX. ASSIGNED
CHAR FLUX SHOULD BE SET TO ZERO (SEE GROUP 16, CARD SET 11).

1 ASSIGNED WALL ENTHALPY.

2 SURFACE EQUILIBRIUM WITH ASSIGNED COMPONENT MASS FLUXES (RE-
QUIRES KR(9) = 2). THE PROBLEM IS WELL-POSED AND WILL CONVERGE
ONLY IF THERE EXISTS A TEMPERATURE ABOVE 250K GIVING SURFACE
EQUILIBRIUM FOR THE ASSIGNED COMPONENT MASS FLUXES. USE WITH
CAUTION FOR ANALYSES OF MATERIALS WITH PLATEAU-LIKE BEHAVIOR.

*** USED FOR ASSIGNED BLOWING RATE ***

COLUMN 12 DETERMINES WHETHER OR NOT NEW DATA FOR THERMODYNAMIC AND
TRANSPORT PROPERTIES ARE TO BE USED AND WHETHER OR NOT
SURFACE KINETIC DATA ARE TO BE CONSIDERED (SEE GROUPS 11,
12, 13, AND 14). APPLIES ONLY FOR KR(7)=0 OR 2. (KR(12) MUST
BE 0 OR 2 FOR FIRST CASE).

0 USER INPUTS NEW DATA FOR ELEMENTS AND MOLECULAR, ATOMIC, AND IONIC
SPECIES. THERMOCHEMICAL DATA NOT PRINTED IN OUTPUT.

1 USES RESIDENT ELEMENTAL AND SPECIES DATA.

2 SAME AS KR(12)=0 EXCEPT THERMOCHEMICAL DATA ARE PRINTED IN OUTPUT.

COLUMN 13

0 SI UNITS I/O

1 ENGLISH UNITS I/O

2 SAME AS 0 EXCEPT PLOT VARIABLES WRITTEN TO UNIT 18 (KPLT)

3 SAME AS 1 EXCEPT PLOT VARIABLES WRITTEN TO UNIT 18 (KPLT)

COLUMN 14 DETERMINES MODEL TO BE EMPLOYED FOR MULTICOMPONENT TRANSPORT PROPERTIES. CONSIDERING UNEQUAL DIFFUSION COEFFICIENTS CAN SUBSTANTIALLY INCREASE THE NUMBER OF ITERATIONS (AND SOMETIMES CONVERGENCE DOES NOT OCCUR IN THE ALLOWED NUMBER OF ITERATIONS) DUE TO THE USE OF INEXACT DERIVATIVES IN THE NEWTON-RAPHSON ITERATION PROCEDURE.

0 CONSIDERS UNEQUAL DIFFUSION AND THERMAL DIFFUSION COEFFICIENTS FOR ALL SPECIES

1 CONSIDERS UNEQUAL DIFFUSION COEFFICIENTS FOR ALL SPECIES BUT NEGLECTS THERMAL DIFFUSION

2 CONSIDERS EQUAL DIFFUSION COEFFICIENTS AND NEGLECTS THERMAL DIFFUSION. **MUST BE USED FOR BINARY DIFFUSION OPTION.**

COLUMN 15 NON-ZERO ENTRY PROVIDES DEBUG OUTPUT FOR FIRST GUESSES AND LINEAR MATRICES (SEE DEBUG INSTRUCTIONS FOR MORE DETAILED INFORMATION ON COLUMNS 15 THROUGH 20)

0 NO DEBUG

1 FIRST GUESSES ARE DUMPED

2 LINEAR MATRICES BEFORE AND AFTER INVERSION ARE ALSO DUMPED

COLUMN 16 NON-ZERO ENTRY PROVIDES DEBUG OUTPUT FOR WALL FLUXES AND SURFACE EQUILIBRIUM ITERATION.

0 NO DEBUG

X FOR X GREATER THAN ZERO, THE DERIVATIVES OF WALL ENERGY AND MASS FLUXES WITH RESPECT TO REDUCED NONLINEAR VARIABLES (DQJRN), AND THE ASSOCIATED ERRORS (WALLOJ AND DELOJW) ARE DUMPED. ALSO, THE MATRIX OF WALL RELATIONS BEFORE AND AFTER MATRIX INVERSION IS DUMPED FOR KR(11)=2 PROBLEMS.

Y FOR Y GREATER THAN UNITY, SURFACE EQUILIBRIUM ITERATION INFORMATION IS ALSO DUMPED (AS IN KR(18)) AND IF KR(17) IS GREATER THAN ZERO, THE DERIVATIVES OF WALL ENERGY AND MASS FLUXES WITH RESPECT TO ALL NONLINEAR VARIABLES (DQJNL) ARE ALSO DUMPED.

COLUMN 17 NON-ZERO ENTRY PROVIDES DEBUG OUTPUT FOR COEFFICIENTS IN NON-LINEAR EQUATIONS AND FOR STREAMWISE DERIVATIVES

0 NO DEBUG

X FOR X GREATER THAN ZERO, STREAMWISE DERIVATIVE INFORMATION IS

DUMPED.

- Y FOR (Y+1-ITS) GREATER THAN ZERO, WHERE ITS IS THE NUMBER OF THE CURRENT BOUNDARY LAYER ITERATION, THE COEFFICIENTS WHICH COMBINE TO MAKE UP THE NONLINEAR EQUATIONS (COEEQV ARRAY) AND CERTAIN LINEAR AND NONLINEAR ERROR INFORMATION ARE DUMPED AND THE DERIVATIVES OF THE NONLINEAR EQUATIONS WITH RESPECT TO THE NONLINEAR VARIABLES (AM ARRAY) ARE DUMPED BEFORE AND AFTER INVERSION,

COLUMN 18 NON-ZERO ENTRY PROVIDES DEBUG OUTPUT FOR CHEMISTRY ITERATION (KR(7) = 0 OR 2 ONLY).

- 0 NO DEBUG
- 1 DUMPS CHEMISTRY ITERATIONS IN DETAIL FOR ITS GREATER THAN 45 WHERE ITS IS THE COUNTER ON CHEMISTRY ITERATIONS
- 2 DUMPS ONE LINE PER ITERATION DURING EACH CHEMISTRY ITERATION
- Y FOR Y OF 3 THROUGH 6, DUMPS CHEMISTRY ITERATIONS IN DETAIL WHEN $(5*(Y-2)-ITS)$ IS GREATER THAN ZERO.
- X FOR X OF 7 THROUGH 9, DUMPS CHEMISTRY ITERATIONS IN DETAIL WHEN ITS IS GREATER THAN $10X-50$.

COLUMN 19 NON-ZERO ENTRY PROVIDES DEBUG OUTPUT FOR LINEAR AND NONLINEAR ERRORS

- 0 NO DEBUG
- 1 DUMPS (FOR EACH ITERATION) THE FOLLOWING. ERRORS FOR NONLINEAR MOMENTUM (FNLE), ENERGY (GNLE), AND SPECIES (SPNLE) EQUATIONS, CORRECTIONS FOR REDUCED NONLINEAR WALL VARIABLES (DRNL=F,G,SP(K)), NONLINEAR VARIABLE ARRAY (DVNL=ALPHA,F(1),FPP(1),(FP(I),I=1,NETA), GP(1),(G(I),I=1,NETA),(SPP(1,K),(SPP(I,K),I=1,NETA),K=1,NSP-1), LINEAR MOMENTUM VARIABLES (FLE), ENERGY VARIABLE (GLE), AND SPECIES VARIABLES (SPLE).

COLUMN 20 NON-ZERO ENTRY PROVIDES DEBUG OUTPUT FOR THERMODYNAMIC AND TRANSPORT PROPERTIES (KR(7) = 0 OR 2 ONLY).

- 0 NO DEBUG
- X FOR X GREATER THAN ZERO, GIVES THERMODYNAMIC AND TRANSPORT PROPERTY INFORMATION FOR EACH CHEMISTRY SOLUTION
- 2 GIVES MATRIX OF PROPERTY DERIVATIVES BEFORE AND AFTER INVERSION.

FIELD 2 (COLUMNS 21-72), CASE

TITLE OF CASE (ALPHANUMERIC). USED FOR IDENTIFICATION OF PRINTED OUTPUT.

GROUP 2 NUMBER OF ELEMENTS (CALLED FROM RECASE)

CARD SET 1 NAMED LIST/MISLIST/ ***USED ONLY FOR KR(1),GE,2***

WHEN SMISLIST IS USED GROUPS 2,3,4,5,7,8, AND 9 ARE NOT USED.

CARD 2, FORMAT(I2,8X,40I1)

FIELD 1 (COLUMNS 1-2, RIGHT-JUSTIFIED), NSP

NUMBER OF ELEMENTS IN THE SYSTEM NOT INCLUDING ELECTRONS (MAX. OF 7)

***FOR BINARY DIFFUSION NSP IS ENTERED AS 2, **

***FOR NONREACTING GAS OPTIONS, NSP=1, **

FIELDS 2-51 (COLUMNS 11-50), KS(M), M=1, NS ***** USED ONLY FOR KR(9)
OR ANY OF THE KR9 = 2, 3, OR 4 *****

(THIS INFORMATION IS USED ONLY FOR ABLATING WALL MATERIAL.)
THE SURFACE MATERIAL IS SPECIFIED IN ADVANCE BY THE USER FOR KR(9) = 2,
3 OR 4. UP TO THREE MATERIAL COMBINATIONS ARE ALLOWED. EACH
COMBINATION MAY HAVE A SEPARATE PYROLYSIS GAS AND CHAR MATERIAL
SPECIFIED IN GROUP 11, FIELD 5. ENTER A 1, 2, OR 3 TO DENOTE MATERIAL
COMBINATION 1, 2, OR 3 STARTING WITH THE STATION 1 ENTRY IN COLUMN 11,
STATION 2 IN COLUMN 12, ETC. SEE ALSO GROUP 6, CARDS 1 AND 2.

GROUP 3 STATION INFORMATION (CALLED FROM RECASE)

CARD 1, FORMAT(I2,8X,40I1)

FIELD 1 (COLUMNS 1-2, RIGHT-JUSTIFIED), NS

NUMBER OF STREAMWISE STATIONS (MAXIMUM OF 40)

FIELDS 2- 41 (COLUMNS 11-50), KR9

VALUES TO BE ASSIGNED TO KR(9) WHEN WALL BOUNDARY CONDITIONS ARE TO BE
CHANGED AT DOWNSTREAM STATIONS (SEE CARD 1 OF GROUP 1). COLUMN 11
CORRESPONDS TO STATION S(1), COLUMN 12 TO STATION S(2), AND SO ON.
IF WALL BOUNDARY CONDITIONS ARE NOT TO BE CHANGED AT DOWNSTREAM
STATIONS, THIS FIELD SHOULD BE LEFT BLANK. WHEN THE KR9() ARE
EMPLOYED, KR(9) SHOULD BE GIVEN THE VALUE NECESSARY TO READ ALL APPROP-
RIATE WALL DATA (GROUP 16).

AT THE PRESENT TIME, IT IS POSSIBLE TO CONSIDER ANY COMBINATIONS OF
KR9 OF 2, 3, AND 4 COMPRISING REGIONS OF AN ABLATION MATERIAL AND
REGIONS WHERE THERE IS NO ABLATION (THESE NONABLATING REGIONS ARE OB-
TAINED BY USE OF KR9() = 2 WHILE ASSIGNING ZERO COMPONENT MASS FLUXES,
SEE CARD SET 11 OF GROUP 16)

CARD SET 2, FORMAT(7E10,4)

FIELD 1 (COLUMNS 1-10) S(1)
S(1) IS NORMALIZED BY RTM, SEE GROUP 5, CARD 1.

FIELD 2 (COLUMNS 11-20), FIELD 3 (COLUMNS 21-30), ETC., 7 FIELDS PER CARD.
S(L), L=2, NS ***USED ONLY FOR KR(6)=4 OR 8***

STREAMWISE DISTANCE UPON WHICH BOUNDARY-LAYER SOLUTION IS BASED, S(L) IS ENTERED IN NORMALIZED FORM - THE NORMALIZING FACTOR BEING RTM INPUT IN GROUP 5, CARD 1. S(1) MUST NOT BE 0. THE VALUE OF S(1) SHOULD BE SELECTED TO REPRESENT THE PHYSICAL DISTANCE FROM THE START OF THE BOUNDARY-LAYER DEVELOPMENT TO THE FIRST SOLUTION STATION. THE BOUNDARY LAYER IS ASSUMED TO BE SIMILAR UP TO AND INCLUDING THIS FIRST STATION. A NEGATIVE ENTRY FOR S(L) SIGNIFIES A DISCONTINUITY AT THAT STATION. THIS PRODUCES A TWO-POINT DIFFERENCE SOLUTION AT THE FIRST STATION AFTER THE DISCONTINUITY AND THUS HAS AN EFFECT ONLY FOR THREE-POINT SOLUTIONS (KR(3)=2), (ALSO SEE CARD SET 3)

*** NOTE *** SIMILAR MEANS THAT NO DERIVATIVES ARE CONSIDERED IN THE TRANSFORMED STREAMWISE COORDINATE DIRECTION.

CARD SET 3 NAMELIST (\$INPUT) ****USED ONLY FOR KR(6)=3,6,7****

WHEN \$INPUT IS USED GROUP 3, CARD SET 2, FIELDS 2,3, ETC.; GROUP 5, CARD SET 2; AND GROUP 15, CARD SET 3 ARE NOT USED.

GROUP 4 NODAL DATA (CALLED FROM RECASE) ** SKIP THIS GROUP FOR KR(1)=0 OR 2**

CARD 1, FORMAT(I2) ***** USED ONLY IF KR(1)=1 *****

FIELD 1 (COLUMNS 1-2, RIGHT-JUSTIFIED), NETA

NUMBER OF NODAL POINTS ACROSS THE BOUNDARY LAYER INCLUDING WALL AND BOUNDARY LAYER EDGE (MAXIMUM OF 15).

CARD SET 2, FORMAT(7E10,4) ***** USED ONLY IF KR(1)=1 *****

FIELD 1 (COLUMNS 1-10), FIELD 2 (COLUMNS 11-20), ETC., 7 TO A CARD,
ETA(I), I=1, NETA (SEE CARD 1 OF THIS GROUP)

ETA STATIONS ACROSS THE BOUNDARY LAYER, STARTING AT WALL (ETA=0.0). IT IS RECOMMENDED THAT THE VALUE OF ETA AT THE BOUNDARY-LAYER EDGE BE GIVEN A VALUE OF ABOUT 5.0 SO THAT THE STRETCHING PARAMETER WILL BE NEAR UNITY. ALSO, THERE SHOULD NOT BE MUCH MORE THAN A TWO-FOLD CHANGE IN DISTANCE BETWEEN TWO NEIGHBORING NODES. BEST ACCURACY FOR A GIVEN NUMBER OF NODES IS OBTAINED IF THE NODES ARE CLOSER TOGETHER NEAR THE WALL. FOR LAMINAR PROBLEMS, 7 NODES ARE OFTEN SUFFICIENT WITH A TYPICAL SPACING BEING 0.0, 0.5, 1.0, 1.5, 2.0, 3.0, 5.0 AND WITH KAPPA = 5, CBAR = 0.8 (SEE CARD 3, FIELDS 1 AND 2 OF THIS GROUP). FOR

TURBULENT BOUNDARY LAYERS, MORE NODES ARE NEEDED CLOSE TO THE WALL DUE TO THE STEEP GRADIENTS THERE. A TYPICAL SPACING WOULD BE 0.0, 0.002, 0.006, 0.01, 0.025, 0.06, 0.15, 0.4, 0.7, 1.0, 1.5, 2.5, WITH $KAPPA = 10$ AND $CBAR = 0.95$. WHATEVER THE NODE SPACING THE USER MUST EXAMINE THE SOLUTIONS TO BE SURE THAT A REASONABLE CURVEFIT IS OBTAINED NEAR THE WALL. THIS CAN BE A PROBLEM FOR LARGE STREAMWISE DISTANCES IN TURBULENT FLOWS. *** NOTE *** USE OF REFIT OPTION MAKES THE INITIAL SELECTION OF NODAL POINTS NON-CRITICAL.

CARD 3 FORMAT (I2,E10.4,2I2,F10.4,3I2) *****USED ONLY IF $KR(1)=1$ *****

FIELD 1 (COLUMNS 1-2, RIGHT-JUSTIFIED). KAPPA

THE VARIABLE KAPPA IS ASSOCIATED WITH THE CONSTRAINT WHICH IS UTILIZED TO EFFECT A STRETCHING OF η , THE BOUNDARY-LAYER COORDINATE NORMAL TO THE SURFACE, IN ORDER TO EFFECTIVELY USE THE ASSIGNED NODAL SPACING (SEE CARDS 1 AND 2 OF THIS GROUP). KAPPA IS THE INDEX FOR THE NODAL POINT AT WHICH THE VELOCITY RATIO IS FIXED. TO ILLUSTRATE, IF KAPPA IS 5, THEN THE FIFTH NODAL POINT COUNTING FROM THE WALL AND INCLUDING THE WALL WILL HAVE A VALUE OF $CBAR$ (A QUANTITY WHICH IS INPUT IN THE SECOND FIELD OF THIS CARD).

FIELD 2 (COLUMNS 3-12), $CBAR$

$CBAR$ IS THE VALUE OF THE VELOCITY RATIO AT THE BOUNDARY-LAYER NODE DESIGNATED KAPPA (SEE DISCUSSION UNDER FIELD 1 OF THIS CARD).

FIELD 3 (COLUMNS 13-14, RIGHT-JUSTIFIED) KONRFT

THE VARIABLE KONRFT DETERMINES IF THE NODAL REFIT OPTION IS TO BE USED. FOR $KONRFT=0$, THE DEFAULT VALUE, REFIT IS NOT CALLED. IF THE REFIT OPTION IS DESIRED, SET $KONRFT = 1$. THE REMAINING FIELDS ON CARD 3 ARE NOT REQUIRED IF $KONRFT = 0$.

FIELD 4 (COLUMNS 15-16, RIGHT-JUSTIFIED) NPOINT

NPOINT IS THE NUMBER OF EXTRA DATA POINTS TO BE USED TO DEFINE EACH POLYNOMIAL SEGMENT DURING REFIT. SHOULD BE SET BETWEEN 1 AND 6. THE HIGHER THE NUMBER, THE GREATER THE DEFINITION OF THE CURVE PRIOR TO REFITTING. GENERALLY FROM 3 TO 5 APPEARS REASONABLE. IF NO VALUE OR 0 IS INPUT A DEFAULT VALUE OF 5 IS USED, IF A VALUE GREATER THAN 6 IS SELECTED, IT IS OVERRIDEN AND REPLACED BY 6.

FIELD 5 (COLUMNS 17-26) RATLIM

IN CONJUNCTION WITH THE VALUES OF $F2FIX$ (SEE CARD 4 BELOW) RATLIM DETERMINES HOW FAR AWAY FROM THE DESIRED VALUE THE VALUE OF $F(2,1)$ IS ALLOWED TO DRIFT BEFORE REFIT IS CALLED. RATLIM IS EXPRESSED AS A RATIO OF THE DIFFERENCE BETWEEN THE DESIRED VALUES OF NEIGHBORING NODES. FOR EXAMPLE IF $F2FIX(2)=0.1$, $F2FIX(3)=0.2$ AND $RATLIM=0.5$, $F(2,2)$ MAY DRIFT UPWARD OR $F(2,3)$ DOWNWARD TO 0.15 BEFORE REFIT IS CALLED. RATLIM MUST BE SELECTED BETWEEN 0.0 AND 1.0. OBVIOUSLY THE SMALLER THE VALUE, THE TIGHTER THE CONSTRAINT ON NODAL POSITIONING. A VALUE OF 0.0 WILL CAUSE REFIT TO BE CALLED AFTER EVERY CONVERGED SOLUTION.

FIELD 6 (COLUMNS 27-28 RIGHT-JUSTIFIED) KTURB

THE SWITCH KTURB DETERMINES IF THE NUMBER OF NODES ARE TO BE CHANGED UPON TRANSITION TO A TURBULENT BOUNDARY LAYER SOLUTION. FOR KTURB=0 (DEFAULT VALUE) NO CHANGE IS MADE. FOR KTURB=1 A SECOND SET OF KAPPA, CBAR, AND F2FIX VALUES ARE REQUIRED AND ARE NAMED, KAPPAT, NETAT, AND F2FIXT WHICH FUNCTION IDENTICALLY TO THEIR ORIGINAL COUNTERPARTS. CURRENTLY THIS OPTION IS LIMITED TO OCCURRING SIMULTANEOUSLY WITH THE TRANSITION TO TURBULENT FLOW, THE REMAINING FIELDS ON CARD 3 ARE NOT REQUIRED IF KTURB=0.

FIELD 7 (COLUMNS 29-30 RIGHT=JUSTIFIED) KAPPAT

KAPPAT HAS THE SAME MEANING AS KAPPA IN FIELD 1 OF THIS CARD AND IS USED IF A CHANGE IN THE NUMBER OF NODES IS TO BE MADE (KTURB=1).

FIELD 8 (COLUMNS 31-32 RIGHT=JUSTIFIED) NETAT

NETAT IS THE NEW NUMBER OF NODES ACROSS THE LAYER FOR KTURB=1.

CARD SET 4 FORMAT (AE10,4) *****USED ONLY IF KONRFT=1*****

FIELD 1 (COLUMNS 1-10), FIELD 2 (COLUMNS 11-20), ETC., 8 TO A CARD, F2FIX(I), I=1,NETA (SEE CARD 1 OF THIS GROUP).

F2FIX(I) IS THE DESIRED DISTRIBUTION OF THE VELOCITY RATIO ACROSS THE BOUNDARY LAYER WHEN THE REFIT OPTION IS EMPLOYED. THE VALUES OF F2FIX MUST GO FROM 0.0 TO 1.0 AND THE VALUE OF F2FIX(KAPPA) MUST EQUAL CBAR.

CARD SET 5 FORMAT (AE10,4) *****USED ONLY IF KONRFT=1 AND KTURB=1*****

FIELD 1 (COLUMNS 1-10) FIELD 2 (COLUMNS 11-20), ETC., 8 TO A CARD, F2FIXT(I), I=1,NETAT (SEE CARD 3 OF THIS GROUP).

F2FIXT(I) IS EQUIVALENT IN MEANING TO F2FIX(I) OF CARD 4 EXCEPT THAT IT APPLIES TO THE CHANGE IN THE NUMBER OF NODES, F2FIX(KAPPAT) MUST EQUAL CBAR.

GROUP 5 BODY SHAPE DATA (CALLED FROM RECASE)

CARD 1 ,FORMAT (E10,4)

FIELD 1 (COLUMNS 1-10) RTM

RTM (METERS) IS USED AS A NORMALIZING FACTOR FOR ALL LENGTH VARIABLES -- S, ROKAP, YITAB. (RTM IS THE THROAT RADIUS FOR NOZZLES.)

CARD SET 2, FORMAT(7E10,4) ***** USED ONLY FOR KR(6) = 4 OR 8 *****

FIELD 1 (COLUMNS 1-10), FIELD 2 (COLUMNS 11-20), ETC., 7 TO A CARD, ROKAP(L), L=1, NS (SEE CARD 3 OF GROUP 3)

THIS IS THE LOCAL BODY RADIUS NORMAL TO THE BODY CENTERLINE NORMALIZED
BY RTH.

GROUP 6 MATERIAL PROPERTY DATA NEEDED FOR WALL QUASI-STEADY ENERGY BALANCE.
(CALLED FROM RECASE) *****CONSIDER THIS GROUP ONLY IF KR(9) OR ANY OF
THE KR9 IS EQUAL TO 3 OR GREATER*****

CARD 1, FORMAT(9E8,3) ** USED ONLY IF KR(9) OR ANY OF THE KR9 IS 3 OR 4 **

FIELDS 1,4,7 (COLUMNS 1-8, 25-32, 49-56), EMIV(I), I=1,3

SURFACE EMITTANCE OF THE MATERIAL COMBINATIONS BEING CONSIDERED UNDER
KR(9) OR KR9 OF 3 OR 4.

FIELDS 2,5,8 (COLUMNS 9-16, 33-40, 57-64), HCARR(I), I=1,3

HEAT OF FORMATION (J/KG) OF THE VIRGIN STATE OF THE ABLATION MATERIALS
BEING CONSIDERED UNDER KR(9) OR KR9 OF 3 OR 4. (CHAR)

FIELDS 3,6,9 (COLUMNS 17-24, 41-48, 65-72), HPYG(I), I=1,3

HEAT OF FORMATION (J/KG) OF THE TRANSPIRANTS BEING CONSIDERED UNDER
KR(9) OR KR9 OF 3 OR 4. (PYROLYSIS GAS)

CARD 2, FORMAT(6A4) ** USED ONLY WITH CARD 1 **

FIELDS 1,2, AND 3 (COLUMNS 1-8, 9-16, 17-24), ASU(I),BSU(I), I=1,3

NAMES OF SURFACE SPECIES FOR MATERIAL COMBINATIONS 1,2, AND 3 EXACTLY AS
THEY APPEAR IN THE THERMODYNAMIC DATA TABLES (GROUP 13, CARD SETS 2,3,
4,...., CARD 1, FIELDS 1-8), LEFT JUSTIFIED.

CARD 3, FORMAT(8E10,4) *** USED ONLY FOR KR(9) OR KR9(L) = 7 ***

ADIABATIC WALL OR TRANSPIRATION COOLED ADIABATIC WALL

FIELD 1 (COLUMNS 1-10) SURFACE EMISSIVITY (MAY BE ZERO)

FIELD 2 (COLUMNS 11-20) ENTHALPY OF INITIAL STATE OF TRANSPIRANT (BTU/
LBM), IF TRANSPIRATION COOLED.

*** NOTE *** INJECTION RATE OF THE TRANSPIRANT IS READ IN AS
PYROLYSIS GAS BLOWING RATE. (FOR HOMOGENEOUS GAS
READ IN TRANSPIRATION FLUX AS RHOVW.)
THE ELEMENTAL COMPOSITION OF THE TRANSPIRANT IS
READ IN AS ELEMENTAL COMPOSITION OF PYROLYSIS GAS
FOR ONE OF THE MATERIAL COMPOSITIONS IN GROUP 11.

GROUP 7 STAGNATION DATA (CALLED FROM RECASE)

CARD 1 ,FORMAT (7E10,4)

FIELD 1 (COLUMNS 1-10) PTET(1)

LOCAL STAGNATION PRESSURE (N/M**2)

FIELD 2 (COLUMNS 11-20) PTET(2)

NORMALIZING FACTOR FOR THE EDGE PRESSURE READ IN UNDER NAMELIST FORM IF THOSE PRESSURES ARE NOT NORMALIZED TO THE STAGNATION PRESSURE.
EX, PITAB ENTERED IN PSIA, ENTER PTET(2) AS THE STAGNATION PRESSURE IN PSIA.

CARD 2 ,FORMAT (7E10,4)

FIELD 1 (COLUMNS 1-10) GE(1)

STAGNATION ENTHALPY OF THE EDGE GAS (J/KG)

CARD 3 ,FORMAT (7E10,4)

FIELD 1 (COLUMNS 1-10) RADFL(1)

INCIDENT RADIATION FLUX ABSORBED BY THE SURFACE AT STATION S(1), J/SEC-M**2. (IF A SURFACE ABSORPTIVITY LESS THAN UNITY IS TO BE CONSIDERED, THIS ENTRY SHOULD BE CORRECTED FOR SURFACE ABSORPTIVITY). THIS INFORMATION IS USED ONLY FOR KR(9) OR KR9 OF 3 OR 4.
INPUT BLANKS IN THIS FIELD FOR OTHER TYPES OF PROBLEMS. RADIATION FLUX AT OTHER STATIONS WILL BE INPUT AS RATIOS IN GROUP 15.

GROUP 8 TURBULENT FLOW PARAMETERS (CALLED FROM TREMBL) **** CONSIDER THIS GROUP ONLY IF KR(7) = 2 OR 3 ****

CARD 1, FORMAT(6E10,3)

FIELDS 1-6, (COLUMNS 1-10, 11-20, 21-30, 31-40, 41-50, 51-60) ELCON, YAP, CLNUM, SCT, PRT, RETR

ELCON IS THE PRANDTL MIXING LENGTH CONSTANT AND IS USED TO IDENTIFY THE TURBULENT MODEL.

YAP IS A CONSTANT OF PROPORTIONALITY IN THE MIXING LENGTH EXPRESSION

CLNUM IS THE CLAUSER CONSTANT OF PROPORTIONALITY IN OUTER WAKE REGION FOR THE KENDALL AND CEBECI MODELS. IT IS A CONSTANT IN THE BUSHNELL MODEL.

TYPICAL INPUT FOR THE THREE TURBULENT MODELS IS GIVEN BELOW.

	ELCON	YAP	CLNUM
KENDALL	.44	11.823	.018
BLISHNELL	.4	0	.08
CEBECI	.4	-11.8	.0168

SCT IS THE TURBULENT SCHMIDT NUMBER, (0.9 IS A TYPICAL VALUE)

PRT IS THE TURBULENT PRANDTL NUMBER, (0.9 IS A TYPICAL VALUE)

A NEGATIVE ENTRY ACTIVATES THE CEBECI MODEL FOR TURBULENT PRANDTL CALCULATION OF PRT. THIS ENTRY IS THEN A CONSTANT IN THE CEBECI EXPRESSION FOR TURBULENT PRANDTL NUMBER (TYPICAL VALUE =0.44)

RETR IS THE TRANSITION REYNOLDS NUMBER BASED ON MOMENTUM THICKNESS. IF RETR IS EXCEEDED, TURBULENCE TERMS WILL BE INCLUDED IN THE GOVERNING EQUATIONS. IF RETR IS NEGATIVE FULL TURBULENCE WILL OCCUR AT STATION IS = IFIX (-RETR)

GROUP 9 FIRST GUESS OR RESTART INFORMATION (CALLED FROM FIRSTG) **** SKIP THIS GROUP FOR KR(2)=2. CONSIDER ONLY CARD 6 FOR KR(2)=0 ****

CARD 1 ,FORMAT (3E10.4,5X,15,E10.4) **** USED ONLY IF KR(2)=1 OR 3 ****

FIELD 1 (COLUMN 1-10) ALPH

FIRST GUESS OR RESTART VALUE FOR BOUNDARY LAYER NORMALIZING PARAMETER (USE A 1.0 IF A BETTER GUESS IS NOT KNOWN).

FIELD 2 (COLUMNS 11-20) F(1,1)

FIRST GUESS OR RESTART VALUE FOR STREAM FUNCTION AT THE WALL.

FIELD 3 (COLUMNS 21-30) F(3,1)

FIRST GUESS OR RESTART VALUE FOR NORMALIZED VELOCITY GRADIENT AT THE WALL.

FIELD 4 (COLUMN 36-40, RIGHT JUSTIFIED) IST

STATION NUMBER FOR RESTART. MEANINGFUL ONLY FOR KR(2)=3.

CARD SET 2, FORMAT(7E10.4) **** USED ONLY FOR KR(2)=1 OR 3 ****

FIELD 1 (COLUMNS 1-10), FIELD 2 (COLUMNS 11-20), ETC., 7 TO A CARD, F(2,I), I=1,NETA.

FIRST GUESSES OR RESTART VALUES FOR VELOCITY RATIO U/U_1 ACROSS THE BOUNDARY LAYER.

CARD SET 3, FORMAT(7E10,4) **** USED ONLY FOR KR(2)=1 OR 3 ****

FIELD 1 (COLUMNS 1-10), FIELD 2 (COLUMNS 11-20), ETC., 7 TO A CARD,
G(2,1), G(1,I), I=1,NETA

FIRST GUESSES OR RESTART VALUES FOR ENTHALPY GRADIENT AT THE WALL G(2,1)
AND ENTHALPY G(1,I) ACROSS THE BOUNDARY LAYER, J/KG.

CARD SET 4, FORMAT(7E10,4) **** USED ONLY FOR KR(2)=1 OR 3 AND NSP GREATER
THAN 1 ****

FIELD 1 (COLUMNS 1-10), FIELD 2 (COLUMNS 11-20), ETC., 7 TO A CARD,
(SP(2,1,K), SP(1,I,K), I=1,NET4) K=1, NSP=1

FIRST GUESSES OR RESTART VALUES FOR ELEMENTAL MASS FRACTION GRADIENT
AT THE WALL SP(2,1,K) AND ELEMENTAL MASS FRACTION VALUES SP(1,I,K)
ACROSS THE BOUNDARY LAYER. READ IN WALL GRADIENT AND VALUES AT NODES
FOR EACH ELEMENT BEFORE GOING ON TO NEXT ELEMENT. START EACH ELEMENT
ON A NEW CARD.

CARD SET 5, FORMAT(36I2) **** USED ONLY FOR KR(2)=1 OR 3 AND IS GREATER
THAN 1 ****

FIELD 1 (COLUMNS 1-2, RIGHT JUSTIFIED), FIELD 2 (COLUMNS 3-4, RIGHT
JUSTIFIED), ETC., (LEF(K), K=1,IS) (SEE CARD 1 OF GROUP 11.)

ENTRIES IN THESE FIELDS MUST INDIVIDUALLY CORRESPOND TO THE ELEMENTS AS
THEY ARE ENTERED IN GROUP 11, CARD SET 2 ACCORDING TO WHETHER, FOR THE
FIRST (OR RESTART) STATION, THE ELEMENT IS:

- 0 NOT PRESENT
- 1 PRESENT DUE TO LOCAL INJECTION
- 2 PRESENT DUE TO UPSTREAM INJECTION (NOT POSSIBLE AT FIRST STATION)
- 3 PRESENT FROM THE EDGE GAS

CARD 6, FORMAT(E10,4) ***** USED ONLY FOR KR(2)=0 *****

FIELD 1 (COLUMNS 1-10), G*

FIRST GUESS FOR ENTHALPY OF THE GAS AT THE WALL, J/KG, IF NO INFORMATION
IS AVAILABLE USE THE VALUE OF THE STAGNATION ENTHALPY (GROUP 7, CARD 2)

GROUP 10 PROPERTY DATA FOR NONREACTING BOUNDARY LAYER (KR(7)=1 OR 3) (CALLED
FROM STAGEN) **** SKIP THIS GROUP FOR KR(7)= 0 OR 2 OR KR(12)= 1 ****

CARD 1, FORMAT(5E10,4) ***** USED ONLY IF KR(7)=1 OR 3 *****

FIELD 1 (COLUMNS 1-10), PRDUM

PRANDTL NUMBER IF CONSIDERED CONSTANT. OTHERWISE, IT IS A CONSTANT IN THE RELATION

$$PR = PRDUM + PRA * T ** PRB + PRC * T ** PRD$$

UNITS FOR T SET BY KU, CARD 3, FIELD 4. PRA, PRB, PRC, AND PRD ARE INPUT IN FIELDS 2, 3, 4 AND 5 OF THIS CARD.

FIELDS 2, 3, 4 AND 5, (COLUMNS 11-20, 21-30, 31-40, AND 41-50), PRA, PRB, PRC, AND PRD, RESPECTIVELY

COEFFICIENTS IN PRANDTL NUMBER RELATION DEFINED UNDER FIELD 1 OF THIS CARD

CARD 2, FORMAT(4E10,4) ***** USED ONLY IF KR(7) = 1 OR 3 *****

FIELD 1 (COLUMNS 1-10), VMUA

COEFFICIENT IN VISCOSITY RELATION (N-S/M² IF KU= 0; LBM/S-FT IF KU= 1)

$$\mu = (VMUA * T ** VMUB) / (VMUC * T + VMUD)$$

UNITS FOR T SET BY KU, CARD 3, FIELD 4. VMUB, VMUC, VMUD ARE INPUT IN FIELDS 2, 3, AND 4 OF THIS CARD.

FIELDS 2, 3, AND 4, (COLUMNS 11-20, 21-30, AND 31-40), VMUB, VMUC, AND VMUD, RESPECTIVELY

COEFFICIENTS IN VISCOSITY RELATION DEFINED UNDER FIELD 1 OF THIS CARD

CARD 3, FORMAT(I3,2X,3I1,2X,3F10,3) *****USED ONLY IF KR(7) = 1 OR 3*****

FIELD 1 (COLUMNS 1-3, RIGHT-JUSTIFIED), NC

NUMBER OF COMPONENTS OF THE GAS MIXTURE

FIELD 2 (COLUMN 6) IFRAC

- 1 COMPOSITION ENTERED IN CARD SET 4 AS RELATIVE MEMBER OF MOLES.
- 2 COMPOSITION ENTERED IN CARD SET 4 AS RELATIVE MASS.

FIELD 3 (COLUMN 7) ITEMP

- 0 TWO TEMPERATURE RANGES OF THERMODYNAMIC CURVE FIT CONSTANTS ENTERED IN CARD SET 5.
- 1 THREE TEMPERATURE RANGES OF THERMODYNAMIC CURVE FIT CONSTANTS ENTERED IN CARD SET 5. **REQUIRES 6 CARD DATA SET IN CARD SET 5.**

FIELD 4 (COLUMN 8) KU

0 PRANDTL NUMBER AND VISCOSITY EXPRESSIONS ENTERED IN DEG K,

1 PRANDTL NUMBER AND VISCOSITY EXPRESSIONS ENTERED IN DEG R.

FIELDS 5-7 (COLUMNS 11-20, 21-30, 31-40) TJ(I), I= 1,3.

THE TJ(I) SERVE AS LIMITS FOR THE TEMPERATURE RANGES OF THE THERMO-
DYNAMIC CURVE FIT CONSTANTS, (MUST BE DEGREES KELVIN)

OPTIONAL LOW RANGE = BETWEEN 50 DEG. K AND TJ(1).

MID RANGE = BETWEEN TJ(1) AND TJ(2).

UPPER RANGE = BETWEEN TJ(2) AND TJ(3).

CARD SET 4, FORMAT(6E10,3)

FIELDS 1, 3, 5, (COLUMNS 1-10, 21-30, 41-50) TK(I,1), I= 1,NC.

AMOUNT OF COMPONENT I IN THE MIXTURE (SEE IFRAC ON CARD 3)

FIELDS 2, 4, 6, (COLUMNS 11-20, 31-40, 51-60) VMWE(I), I= 1,NC.

MOLECULAR WEIGHT OF COMPONENT I.

*** NOTE *** TK(I,1), VMWE(I) ARE ENTERED AS PAIRS, 3 PAIRS TO A
CARD. THEY **MUST** BE IN THE SAME ORDER AS THE
COMPONENT THERMODYNAMIC DATA CARDS IN CARD SET 5.

CARD SET 5

CURVE FIT CONSTANTS FOR ENTHALPY, SPECIFIC HEAT, AND ENTROPY. SEE
FORMAT IN GROUP 13, CARD SETS 2,3,... FOR ITEM = 1 THE LOW TEMP-
ERATURE CONSTANTS ARE USED.

*** NOTE *** NO BLANK CARD AT END OF GROUP 10.

GROUP 11 ELEMENTAL DATA (CALLED FROM INPUT)

***** SKIP THIS GROUP FOR KR(12)= 1 OR FOR KR(7)= 1 OR 3 *****

CARD 1, FORMAT(I3,F7,0,5F10,4) ***** USED ONLY FOR KR(12)=0 OR 2 *****

FIELD 1 (COLUMNS 1-3, RIGHT-JUSTIFIED), IS

NUMBER OF ELEMENTS IN THE SYSTEM INCLUDING ELECTRONS IF CONSIDERED (THIS
ENTRY WILL BE THE SAME AS CARD 1 OF GROUP 2 (EXCEPT FOR THE DIFFERENT
FORMAT) FOR SYSTEMS NOT CONTAINING ELECTRONS BUT WILL BE ONE GREATER FOR
SYSTEMS CONTAINING ELECTRONS)

FIELDS 2 AND 3 (COLUMNS 4-10,11-20) FFAR, FITMOL

CONSTANTS IN THE CURVEFIT OF FF(J) IN TERMS OF MOLECULAR WEIGHT..

$$FF(J) = (WTM(J)/FITMOL) ** FFAR$$

FFAR AND FITMOL ARE PRESUMED TO BE 0.489 AND 26.7 IF NO ENTRY IS MADE.

FIELDS 4, 5, AND 6 (COLUMNS 21-30, 31-40, 41-50) BASHOL, SIGMA, EPOVRK

THESE ARE PRESUMED TO BE 32.0 , 3.467 , AND 106.7 RESPECTIVELY IF NO ENTRY IS MADE.

*** NOTE FOR FIELDS 2-6 ***

THESE VARIABLES DEFINE THE REFERENCE SPECIES PROPERTIES FOR FF(J) - (AEROTHERM FINAL REPORT NO. 69-53, JULY 1969). BASHOL IS THE MOLECULAR WEIGHT OF THE REFERENCE SPECIES. SIGMA AND EPOVRK ARE THE SPECIES SIGMA AND EPSILON/K AS DEFINED BY SVEHLA ('ESTIMATED VISCOSITIES AND THERMAL CONDUCTIVITIES OF GASES AT HIGH TEMPERATURES', NASA TR-R-132, 1964). STANDARD VALUES DESCRIBED IN AEROTHERM REPORT 69-53 ARE USED IF NO ENTRIES ARE MADE.

FIELD 7 (COLUMNS 51-60) TF(N+1) **** USED ONLY FOR KR(9) = 2 WITH KR(11) = 0 ****

ABLATION TEMPERATURE (DEG K), ABOVE WHICH EQUILIBRIUM CHAR REMOVAL RATE WILL BE DETERMINED. BELOW THIS TEMPERATURE, SURFACE EQUILIBRIUM IS SUPPRESSED. AUTOMATICALLY SET TO 50,000 K IF NO ENTRY. AN ABLATION TEMPERATURE MUST BE ENTERED IF SURFACE CHEMISTRY IS TO BE CONSIDERED.

CARD SET 2

CARDS 1,2,3,..., IS (ONE FOR EACH ELEMENT, SEE CARD 1, FIELD 1 OF THIS GROUP),
FORMAT (1X,A2,3A4,8F7,3) **** USED ONLY FOR KR(12)=0,2,5, OR 7 ***

FIELD 1 (COLUMNS 2-3 ***LEFT JUSTIFIED***) KAT(K)

ATOMIC SYMBOL OF ELEMENT (E FOR ELECTRON), WITH ELECTRON LAST (WHEN CONSIDERED).

FIELD 2, (COLUMNS 4-15) ATA(K), ATB(K), ATC(K)

NAME OF ELEMENT (USED FOR OUTPUT ONLY), FOR BEST LOOKING OUTPUT, ELEMENTS WITH 3 OR 4 LETTERS (EG., IRON) SHOULD START IN COLUMN 6, ELEMENTS WITH 5, 6, OR 7 LETTERS (EG., CARBON) SHOULD START IN COLUMN 5, AND ELEMENTS WITH 8 OR MORE LETTERS (EG., NITROGEN) SHOULD START IN COL. 4.

FIELD 3 (COLUMNS 16-22), WAT(K)

ATOMIC WEIGHT OF ELEMENT

FIELD 4 (COLUMNS 23-29) TK(K,1)

AMOUNT OF ELEMENT IN BOUNDARY-LAYER EDGE GAS. SEE BELOW FOR UNITS.

FIELDS 5 TO 10 (COLUMNS 30-36, 37-43, 44-50, 51-57, 58-64, 65-71) TK(K,J)
J=2,7

AMOUNT OF ELEMENT IN PYROLYSIS GAS AND CHAR FOR EACH OF THE THREE ALLOWABLE MATERIALS. FIELDS 5 AND 6 ARE FOR MATERIAL 1, FIELDS 7 AND 8 FOR MATERIAL 2, ETC. NEGATIVE VALUES ARE USED TO DESIGNATE RELATIVE MASSES OF ELEMENTS, WHEREAS POSITIVE VALUES ARE USED TO DESIGNATE RELATIVE NUMBERS OF ATOMS. AS AN EXAMPLE OF THE LATTER, THE ENTRIES FOR A SILICA CHAR COULD BE 1, FOR THE ELEMENT SILICON AND 2, FOR OXYGEN.

GROUP 12 DIFFUSION FACTOR DATA (CALLED FROM INPUT)

**** SKIP THIS GROUP FOR KR(7)= 1 OR 3 OR KR(12)= 1 OR IF IT IS DESIRED TO USE THE MOLECULAR WEIGHT APPROXIMATION FOR DIFFUSION FACTORS (SEE FIELDS 2 AND 3 OF CARD 1 OF GROUP 11).

CARD 1, FORMAT(15) ***** USED ONLY FOR KR(12)=0 OR 2, AND THEN ONLY IF IT IS DESIRED TO READ IN DIFFUSION FACTOR DATA FOR ONE OR MORE SPECIES *****

FIELD 1 (COLUMNS 1-5, RIGHT-JUSTIFIED) NFF

NUMBER OF MOLECULES FOR WHICH DIFFUSION FACTOR DATA ARE TO BE READ (SEE FIELDS 2 AND 3 OF CARD 1 OF GROUP 11).

CARD SET 2

CARDS 1,2,3,.... AS REQUIRED (DIFFUSION FACTOR DATA REQUESTED BY CARD 1 OF THIS GROUP ARE ENTERED HERE 3 TO A CARD) FORMAT(3(2A4,E12.4))
***** USED ONLY FOR KR(12)=0 OR 2, AND THEN ONLY IF THE CONDITIONS OF CARD 1 OF THIS GROUP ARE MET *****

FIELDS 1, 3, AND 5 (COLUMNS 1-8, 21-28, AND 41-48 RESPECTIVELY)
NFIA(4) AND NFIB(4) IN EACH FIELD

NAME OF MOLECULE AS IT APPEARS IN COLUMNS 1-8 ON FIRST CARD OF 4-CARD THERMODYNAMIC DATA SET FOR THE MOLECULE (SEE GROUP 13, CARD SETS 2,3, 4,...., CARD 1)

FIELDS 2, 4, AND 6 (COLUMNS 9-20, 29-40, AND 49-60 RESPECTIVELY)
FFIN(4) IN EACH FIELD

A SET OF FF(J) AND G(J) ARE INCLUDED IN THE PROGRAM. IF ANY OF THESE ARE TO BE CHANGED, THE NEW VALUES FOR EACH OF THE SPECIES NAMED IN FIELDS 1,3,5,ETC. ARE ENTERED HERE UNDER THE VARIABLE NAME FFIN(J). NEGATIVE ENTRIES OF FFIN REFER TO G(J). THEY ARE THEN SORTED BY SPECIES NAME AND ENTERED INTO THE PROPER SLOTS IN THE FF(J) OR G(J) ARRAYS. THESE DIFFUSION FACTORS ARE REFERENCED TO OXYGEN (O2) OR OTHER REFERENCE SPECIES INDICATED IN GROUP 11. TO OBTAIN ACCURATE VISCOSITY CALCULATIONS USE

$$G(J) = (\text{SIGMA}(J) * \text{WTM}(J) ** .25 * \text{EPOVRK}(J) ** .0795) / (\text{SIGMA}(\text{REF}) * \text{WTM}(\text{REF}) ** .25 * \text{EPOVRK}(\text{REF}) ** .0795)$$

GROUP 13 THERMOCHEMICAL DATA (CALLED FROM INPUT)

***** SKIP THIS GROUP FOR KR(7)= 1 OR 3 OR KR(12)= 1 *****

THERE ARE FOUR CARDS FOR EACH MOLECULAR, ATOMIC, CONDENSED, OR IONIC SPECIES. A TOTAL OF 70 SPECIES OF ALL TYPES ARE ALLOWED, THE NUMBER OF ALLOWABLE CONDENSED-PHASE MATERIALS WHICH CAN BE SIMULTANEOUSLY PRESENT IN ANY SOLUTION IS 4. ANY NUMBER OF CONDENSED PHASE SPECIES CAN BE INCLUDED IN THE THERMOCHEMICAL DATA DECK. (NOTE... CONDENSED SPECIES ARE REQUIRED IN SURFACE EQUILIBRIUM CALCULATIONS FOR CONSIDERATION AS CANDIDATE SURFACE MATERIALS BUT ARE NOT PRESENTLY CONSIDERED AS CANDIDATE SPECIES WITHIN THE BOUNDARY LAYER). A BLANK CARD AFTER THE LAST SET CONCLUDES THE THERMODYNAMIC DATA. THE ARRANGEMENT OF THESE CARD SETS IS OF CONSEQUENCE IN SO FAR AS IT DETERMINES THE BASE SPECIES UPON WHICH MASS BALANCES ARE PERFORMED, THE FIRST INDEPENDENT SET OF BASE SPECIES BEING SELECTED. SINGULAR MATRICES CAN RESULT FROM CERTAIN SETS OF THEORETICALLY ACCEPTABLE BASE SPECIES DUE TO ROUND-OFF ERRORS. FURTHERMORE, MASS BALANCES, ETC. FOR THE (NSP)TH BASE SPECIES (SEE CARD 1 OF GROUP 2) IS OBTAINED BY DIFFERENCE. THEREFORE, THE ELEMENT REPRESENTED BY THIS BASE SPECIES SHOULD BE PRESENT IN APPRECIABLE QUANTITIES THROUGHOUT THE BOUNDARY LAYER. FOR EXAMPLE, FOR ABLATION IN AIR, MOLECULAR NITROGEN IS A GOOD CHOICE FOR THE (NSP)TH BASE SPECIES.

A MULTIPLE PHASE SPECIE SHOULD BE ENTERED TOGETHER IN ORDER OF ASCENDING TEMPERATURE RANGES. THE GAS PHASE AND TWO PHASES OF ANY COMBINATION OF SOLID AND LIQUID ARE ALLOWED. EXCEPT FOR THESE CONSIDERATIONS, ATOMIC, MOLECULAR, AND CONDENSED SPECIES CAN BE ARRANGED IN ANY ORDER. WHEN IONIZED FLOWS ARE CONSIDERED, THE ATOMIC, MOLECULAR AND CONDENSED SPECIES DATA MUST APPEAR FIRST AND BE FOLLOWED BY, FIRST, ELECTRON SPECIES DATA, AND THEN THE IONIC SPECIES DATA (WHICH CAN BE IN ANY ORDER). THE DATA FORMAT ACCEPTED BY THE PROGRAM (DESCRIBED BELOW) IS AS GENERATED BY 'FORTRAN IV PROGRAM FOR CALCULATION OF THERMODYNAMIC DATA' DESCRIBED IN NASA TN D-4097, AUGUST 1967.

***** NOTE ***** THESE CARDS ARE NOT SEQUENTIALLY IDENTIFIED IN COLUMNS 73-80 WITH THE SYSTEM USED ELSEWHERE.

CARD 1 ,FORMAT (I5,3F10.3,I5)

FIELD 1 (COLUMN 1-5) NOT USED

FIELD 2,3,4 (COLUMNS 6-15,16-25,26-35) TJ(I),I=1,3

TEMPERATURE RANGES FOR THE TEMPERATURE COEFFICIENTS. (MUST BE DEG K)

OPTIONAL LOW RANGE = BETWEEN 50 DEG AND TJ(1).

MID RANGE = BETWEEN TJ(1) AND TJ(2).

UPPER RANGE = BETWEEN TJ(2) AND TJ(3).

FIELD 5 (COLUMNS 36-40) ITEM P

- 0 TWO RANGES OF THERMODYNAMIC PROPERTY DATA.
- 1 THREE RANGES OF THERMODYNAMIC PROPERTY DATA.

CARD SETS 2,3,4,... ONE FOR EACH MOLECULE

CARD 1 ,FORMAT (3A4,6X,2A3,4(A2,F3,0),A1,2F10,3,14X,11)

FIELD 1 (COLUMNS 1-12), ISN(I), I=1,3

SPECIES NAME EX. = H2O, USED FOR INPUT/OUTPUT AND AS IDENTIFIER FOR GROUP 6 AND GROUP 12 INPUT.

FIELD 2 (COLUMNS 19-24), ISN(I), I=4,5

DATE OF THE DATA USED FOR THE CURVE FIT.

FIELDS 3,4,5,6,... (COLUMNS 25-26,27-29,30-31,32-34,35-36,37-39,40-41,42-44) JAT(I),ALPT(I), I=1,4

JAT(I) = ATOMIC SYMBOL OF THE ELEMENTS IN THE MOLECULE (LEFT JUSTIFIED)
ALPT(I) = NUMBER OF ATOMS OF JAT(I) IN THE MOLECULE

FIELD 11 (COLUMN 45), JP

PHASE OF THE MOLECULE (S,L,G)

WHEN A SPECIES HAS SEVERAL PHASES THERE IS ONE 4-CARD SET FOR EACH PHASE. THE SETS ARE ORDERED WITH THE LOW TEMPERATURE PHASES FIRST. (SEE DISCUSSION AT THE BEGINNING OF THIS GROUP.)

FIELDS 12,13 (COLUMNS 46-55,56-65) SPL,SPU

SPL = LOWER TEMPERATURE LIMIT FOR THIS MOLECULE IN THIS PHASE (DEG K)
SPU = UPPER TEMPERATURE LIMIT FOR THIS MOLECULE IN THIS PHASE (DEG K)

*** NOTE *** FOR SOLID PHASE, SPU IS THE FILL TEMP. FOR THIS SPECIES AS A SURFACE.

THIS INFORMATION APPLIES ONLY TO THE RANGE OF VALIDITY OF THE CURVE FIT DATA GIVEN ON CARDS 2-4 AND DOES NOT APPLY TO CARDS 5 AND 6 WHEN USED.

FIELD 14 (COLUMN 80) IC1

ENTER A 1

CARD 2 ,FORMAT (5E15.8,I5)

FIELDS 1-5 (COLUMNS 1-15,16-30,31-45,46-60,61-75)

COEFFICIENTS A(I), I=1,5 FOR CP,H,S (SEE BELOW)

FIELD 6 (COLUMN 80)

ENTER A 2

CARD 3 ,FORMAT (5E15,8,15)

FIELDS 1-5 (COLUMNS 1-15,16-30,31-45,46-60,61-75)

COEFFICIENTS A(I), I=6,7 B(I), I=1,3 FOR CP,H,S (SEE BELOW)

FIELD 6 (COLUMN 80)

ENTER A 3

CARD 4 FORMAT (5E15,8,15)

FIELDS 1-4 (COLUMNS 1-15,16-30,31-45,46-60)

COEFFICIENTS B(I), I=4,7 FOR CP,H,S (SEE BELOW)

FIELD 5 NOT USED

FIELD 6 (COLUMN 80)

ENTER A 4

*** CARDS 5 AND 6 USED ONLY FOR ITEMP= 1 AND ONLY FOR GAS PHASE SPECIES.
NOT USED FOR SOLID OR LIQUID PHASE EVEN WHEN ITEMP= 1. ***

CARD 5, FORMAT(5E15,8,15)

FIELDS 1-5 (COLUMNS 1-15, 16-30, 31-45, 46-60)

COEFFICIENTS C(I), I= 1-5 FOR CP, H, S (SEE BELOW)

FIELD 6 (COLUMN 80)

ENTER A 5

CARD 6, FORMAT(5E15,8,15)

FIELDS 1-2 (COLUMNS 1-15, 16-30)

C(6), C(7)

FIELDS 3-5 NOT USED

FIELD 6 (COLUMN 80)

ENTER A 6

THE A(I) APPLY TO THE UPPER TEMPERATURE RANGE, THE B(I) APPLY TO THE
MIDDLE TEMPERATURE RANGE, AND THE C(I) APPLY TO THE OPTIONAL LOW TEMP-
ERATURE RANGE IN THE EQUATIONS-

$$CP/R=A(1)+A(2)*T+A(3)*T**2+A(4)*T**3+A(5)*T**4$$

$$H/(R \cdot T) = A(1) + A(2) \cdot T/2 + A(3) \cdot T^2/3 + A(4) \cdot T^3/4 + A(5) \cdot T^4/5 + A(6)/T$$

$$S/R = A(1) \cdot \text{ALOG}(T) + A(2) \cdot T + A(3) \cdot T^2/2 + A(4) \cdot T^3/3 + A(5) \cdot T^4/4 + A(7)$$

WHERE T IS IN DEGREES K.

AS MENTIONED BEFORE THE LAST CARD IN GROUP 13 IS A BLANK CARD (IDENTIFIED AS 13LAST IN COLUMNS 73-78).

GROUP 14 ***** NOT USED FOR THIS VERSION *****

THIS GROUP RESERVED FOR INPUT OF SURFACE OR GAS PHASE KINETIC DATA.

GROUP 15 STREAMWISE DISTRIBUTIONS FOR EDGE CONDITIONS (CALLED FROM REFCN)

CARD SET 1 NAMELIST/STALIS/ ***USED ONLY FOR KR(1),GE,2***

WHEN SSTALIS IS USED GROUPS 15 AND 16 ARE NOT USED.

CARD SET 2, FORMAT(7E10,4) ***** USED ONLY FOR KR(5)= 5 *****

FIELD 1 (COLUMNS 1-10), FIELD 2 (COLUMNS 11-20), ETC., 7 TO A CARD,
DSIP(L), L=1, NS

DECREASE IN EDGE ENTROPY FROM PREVIOUS STATION TO CURRENT STATION. FOR FIRST STATION THIS IS A DECREASE FROM STAGNATION ENTROPY, J/KG-K

CARD SET 3, FORMAT(7E10,4) ***** USED ONLY FOR KR(6)=4,8 *****

FIELD 1 (COLUMNS 1-10), FIELD 2 (COLUMNS 11-20), ETC., 7 TO A CARD,
PRE(L), L=1, NS (SEE CARD 3 OF GROUP 3)

RATIO OF LOCAL STATIC TO STAGNATION PRESSURE. IN ADDITION TO DEFINING THE LOCAL PRESSURE, THIS DATA IS USED TO FORM THE LOCAL VELOCITY GRADIENT AT OTHER BODY STATIONS.

CARD SET 4, FORMAT(7E10,4)

FIELD 1 (COLUMNS 1-10), FIELD 2 (COLUMNS 11-20), ETC., 7 TO A CARD,
RADR(L), L=1, NS (SEE CARD 3 OF GROUP 3)

RATIO OF LOCAL TO STAGNATION POINT INCIDENT RADIATION. THIS INFORMATION IS USED ONLY FOR KR(9) OR KR9 OF 3 OR 4 INPUT BLANKS INTO THIS FIELD

FOR OTHER TYPES OF PROBLEMS. (NOTE = NUMBER OF CARDS IN CARD SET 3 = NC
WHERE NC IS THE SMALLEST INTEGER SATISFYING $7*NC \geq NS$ (CARD 1,
GROUP 3))

GROUP 16 STREAMWISE DISTRIBUTIONS FOR INPUT WALL CONDITIONS
(CALLED FROM REFCN)

CARD SET 1, FORMAT(7E10,4) ** USED ONLY FOR $KR(11)=1$ AND $KR(9)=0,1,2$ OR 3 **

FIELD 1 (COLUMNS 1-10), FIELD 2 (COLUMNS 11-20), ETC., 7 TO A CARD,
 $HW(L,1)$, $L=1,NS$ (SEE CARD 3 OF GROUP 3)

ENTHALPY OF THE GAS AT THE WALL, J/KG,

CARD SET 2, FORMAT(7E10,4) ** USED ONLY FOR $KR(11)=0$ AND $KR(9)=0,1,2$ OR 3 **

FIELD 1 (COLUMNS 1-10), FIELD 2 (COLUMNS 11-20), ETC., 7 TO A CARD,
 $TW(L,1)$, $L=1,NS$ (SEE CARD 3 OF GROUP 3)

WALL TEMPERATURE, DEG K

CARD SET 3, NOT USED IN THIS VERSION.

CARD SET 4, FORMAT(7E10,4) *** USED ONLY FOR $KR(9)=1$ AND $KR(11)=0$ OR 1 ***

FIELD 1 (COLUMNS 1-10), FIELD 2 (COLUMNS 11-20), ETC., 7 TO A CARD,
 $RHOVW(L,1)$ $L=1,NS$.

TOTAL MASS FLUX AT THE WALL (KG/S-M²).

POSITIVE FOR MASS INJECTION.

CARD SET 5, FORMAT(7E10,4) *** USED ONLY FOR $KR(7)=0$ OR 2, $KR(9)=0$ OR 1,
AND $KR(11)=0$ OR 1.

FIELD 1 (COLUMNS 1-10), FIELD 2 (COLUMNS 11-20), ETC., 7 TO A CARD,
 $SPW(K,L,1)$, $L=1,NS$. DO LOOP FOR $K=1, NSP-1$. NOT USED FOR $NSP=1$.

WALL ELEMENTAL MASS FRACTIONS IN THE SAME ORDER THAT THEY ARE SELECTED
FROM THE THERMODYNAMIC DATA (GROUP 13)

CARD SET 6, FORMAT(7E10,4) **** USED ONLY FOR $KR(7)=0$ OR 2 WITH $KR(9)=2$ AND
 $KR(11)=0,1$, OR 2, OR WITH ANY OF THE $KR(9)=2$

FIELD 1 (COLUMNS 1-10), FIELD 2 (COLUMNS 11-20), ETC., 7 TO A CARD,
ON $N=1,3$ $FLUXJ(N,L,1)$, $L=1,NS$ (SEE CARD 3 OF GROUP 3)

WALL MASS FLUXES OF BOUNDARY-LAYER EDGE GAS, PYROLYSIS GAS, AND CHAR,
RESPECTIVELY (SEE GROUP 11, CARD SET 2, FIELD 4), KG/SEC-M**2, POS-
ITIVE FOR MASS INJECTION.

READ IN ALL EDGE GAS VALUES, THEN START PYROLYSIS GAS VALUES ON A NEW

CARD AND READ ALL PYROLYSIS GAS VALUES, ETC.
*** NOTE *** IF NO MASS FLUXES, THE PROPER NUMBER OF BLANK CARDS MUST BE
ENTERED HERE. (NUMBER OF CARDS=3 TIMES NUMBER OF CARDS IN
CARD SET 1 OR CARD SET 2, WHICH EVER IS USED.)

*** TRANSPIRATION COOLING RATE CAN BE SPECIFIED HERE AS A PYROLYSIS GAS
FLUX ***

GROUP 17 (CALLED FROM BLIMP)

CARD 1 FORMAT(A1)

FIELD 1 (COLUMN 1), JAST

THE PURPOSE OF THIS ENTRY IS TO PERMIT A TEST ON WHETHER OR NOT A NEW
CASE IS TO FOLLOW. IN THE EVENT A CASE DOES NOT CONVERGE IN THE ALLOTTED
NUMBER OF ITERATIONS, ANY REMAINING CARDS FOR THAT CASE ARE READ AND
THEN IGNORED UNTIL A COMMA (,) OR A PERIOD (.) IS ENCOUNTERED IN
COLUMN 1. A COMMA SIGNIFIES ANOTHER CASE, WHILE A PERIOD
SIGNIFIES THAT THERE ARE NO CASES TO FOLLOW.

SECTION 6

CODE USAGE

The purpose of this section is to expand on the information presented in the input description. Several types of problems are discussed with respect to the program options used to model the problem. In addition, several special program options and the interface of BLIMP-J with other JANNAP programs are described. Finally, a description of common convergence difficulties is presented.

6.1 UNITS

Input and output for the BLIMP-J program can be either SI or English engineering units (see discussion in Section 5). The output headings are changed as appropriate. Table 6-1 gives the conversion factors for the two systems.

TABLE 6-1. CONVERSION FACTORS

<u>SI</u>	<u>Multiply by to Get</u>	<u>English Engineering</u>
kg/m ³	UCD(0.062427962)	lbm/ft ³ (density)
Joules/kg	UCE(4.3021-04)	Btu/lbm
meters	UCL(3.28084)	feet (length)
kg	UCM(2.2046226)	lbm (mass)
N/m ²	UCP(9.86923-06)	atmospheres (pressure)
Joules/m ²	UCR(8.8114-05)	Btu/ft ²
N/m ²	UCS(0.020885434)	lbf/ft ² (shear)
°K	UCT(1.8)	°R (temperature)
N-s/m ²	UCV(0.671968995)	lbm/sec-ft (viscosity)
Watts	9.4845-04	Btu/sec
N	0.224809	lbf

6.2 WALL BOUNDARY CONDITIONS

Wall boundary conditions for the BLIMP program have been generalized to include surface thermochemistry considerations. These wall boundary conditions are flagged by various combinations of the KR(9), KR9(L), and KR(11) flags. The input of wall information is controlled by KR(9) and KR(11). The type of wall boundary

condition is controlled by KR(11) and KR9(L). The KR9(L) (Group 3, Card 1, Fields 2-51) can be assigned a different value at each solution station. If no input is made the default value is KR(9).

For those options involving transpiration cooling or surface ablation, the following general rules apply:

- For user specified amount of transpirant or pyrolysis gas use the input fields allocated to "Pyrolysis Gas". (Groups 6, 11, or 16)
- If the program is to compute the amount of transpirant on ablation gas used input fields allocated to "Char". (Groups 6, 11, or 16)

It is possible to specify up to three different materials as possible surface materials at each solution station. The choice of surface materials is governed by KS(L) (Group 2, Card 2, Fields 2-51).

For typical engineering problems, there are several sets of boundary conditions which are used most often. These are typically combinations of the following conditions:

- Chemical equilibrium between the gaseous boundary layer and the surface material
- Assigned surface temperature
- Assigned surface mass flux
- Energy balance between the surface material and the gaseous boundary layer assuming steady state ablation.

Of course, these four conditions cannot be used in all possible combinations and do not constitute a complete list. Several combinations which can be used in the BLIMP program and the control card punches necessary to flag them are described below.

6.2.1 Assigned Surface Temperature, Nonreacting Gas

Use KR(9) = 1, KR(11) = 0, and KR(7) = 1 or 3. This is a simple problem and bypasses all the chemical equilibrium considerations. The homogeneous (nonreacting) gas option is discussed in Section 6.3.

6.2.2 Assigned Surface Temperature, Nonreacting Wall

Use KR(9) = 2 and KR(11) = 0. This option is the same as that of Section 6.2.1 except that gas phase equilibrium chemistry is required. All mass fluxes in Group 16 are entered as zero.

6.2.3 Assigned Surface Temperature and Mass Flux

Use $KR(9) = 2$ and $KR(11) = 0$. This option can be used to model a design problem wherein the desired wall temperature and the amount of transpiration cooling are known and the heat flux to the wall is desired. The transpirants are entered as pyrolysis gases. No surface material-surface gas interaction is considered (see Group 11, Card 1, Field 7).

6.2.4 Assigned Temperature and Surface Equilibrium

Use $KR(9) = 2$ and $KR(11) = 0$. The surface equilibrium option is activated when the assigned wall temperature exceeds the assigned ablation temperature (Group 11, Card 1, Field 7). The assigned char flux should be zero. (A pyrolysis gas flux may be assigned.) The program will choose the correct surface species from the available solid species. The thermochemistry deck must contain at least one solid species whose fail temperature (entered as SPU, Group 13) is greater than the assigned wall temperature.

6.2.5 Steady State Energy Balance and Surface Equilibrium

Use $KR(9) = 4$, $KR(11) = 0$. $KR9(L)$ is equal to 4 at those stations where a special surface chemistry package based on vapor pressures is called. The special chemistry package does not allow fail temperatures and the surface material must be specified in advance (char, Group 6). Within these limitations, the program will calculate the correct mass loss rate of specified surface material necessary to satisfy the steady state energy balance equation. There must be at least one solid phase species in the species deck (Group 13) and its name must correspond to the material name entered in Group 6 as "char". No entry for wall temperature is made in Group 16.

6.2.6 Assigned Surface Temperature and Wall Heat Flux

Use $KR(9) = 3$, $KR(11) = 0$. This option could be used to determine how much transpiration cooling would be required to maintain a specified wall temperature and a specified heat removal rate (by internal cooling). The specified wall heat flux is entered as a negative "radiation absorbed by the surface" using $RADFL(1)$ (Group 7) and $RADR(L)$ (Group 15). The composition of the transpirant is entered as "char" in Groups 6 and 11. No solid phase surface species is required and surface-gas equilibrium is not imposed.

6.2.7 Adiabatic Wall with Transpiration Cooling

Use $KR(9) = 2$, $KR(11) = 0$, and $KR9(L) = 7$, as appropriate. The flux of transpirant is entered as pyrolysis gas flux in Group 16, and blank cards must be used for the wall temperature entered in Group 16. The composition and initial enthalpy of

the transpirant are entered in Group 11 and Group 6, respectively. The wall boundary condition is set by $KR(9) = 7$ and requires zero net energy flux to the wall. For a completely adiabatic wall the transpirant fluxes are omitted and $KR(9) = 7$ is used.

6.3 HOMOGENEOUS GAS OPTION

The homogeneous, or nonreacting, gas option is activated by $KR(7) = 1$ or 3. In this option the user specifies the species composition of the gas and the gas viscosity and Prandtl number as functions of temperature. (The input for this option is described in Group 10.) This option is useful for one-species gases or for preliminary studies where complete accuracy is sacrificed for reduced computer time. An example of the first case is low temperature air flow. For this case the thermodynamic properties, viscosity, and Prandtl number are well known and can easily be curve fit for input to the code. For the second case the main problem is how to get the transport properties of a multicomponent mixture. A program such as the Aerotherm Chemical Equilibrium program (Reference 7) can be used to generate values of the transport properties for frozen species composition. These can then be curve fit as required by the Group 10 input. The gas composition may be frozen at any state, for example, the throat composition. Using this method for a complex gas mixture can result in considerable savings in computer time.

6.4 BINARY DIFFUSION OPTION

The binary diffusion option offers another method of reducing computation time for those gas systems containing more than two elements. Sample case 3, Section 8.3, which has four elements required about 60 percent as much time using the binary diffusion option as it did with the regular options. The remainder of this section is devoted to describing the input manipulations required to activate the binary diffusion option.

The most important aspect of the input for the binary model is the construction of two artificial species which will be considered as diffusing into each other. General guidelines for these two species are given below:

- The entire elemental composition of the system must be represented by the two artificial species
- For problems with gas injection the injectant and the edge gas make up the two artificial species
- The artificial species should be considered as solids with large negative entropies. This can be accomplished by inputting $A(7)$ and $B(7)$ in Group 13 as ~ -1000 . The other entries for the thermodynamic data can be zero.

SPU can be entered as 100. In this way these species will never appear as part of the chemical system and will only serve to keep track of elemental diffusion.

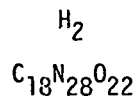
- The artificial species should be the first two in the Group 13 input and if there is an injectant the species representing the injectant should be first and the species representing the edge gas second.

The only additional input required is that NSP in Group 2 should be input as 2 regardless of the number of elements in the problem and $KR(14) = 2$ is used.

As an example of how to construct the artificial species consider a propellant gas of composition* (weight percent):

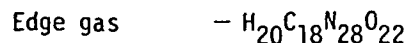
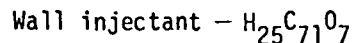
H — 4.0 percent
C — 21.6 percent
N — 38.7 percent
O — 35.7 percent

Alternately the composition could be approximately represented as 40 atoms of H, 18 atoms of C, 28 atoms of N, and 22 atoms of O. This is more convenient for forming fictitious species and for input in Group 11. Two fictitious molecules which could be used to represent this gas are



As it turns out H_2 is a real species and the appropriate thermodynamic data should be used. The C, N, and O have been arbitrarily lumped together.

If this same gas were used in conjunction with an injectant (or ablative wall) with composition** given by 25 atoms of H, 71 atoms of C and 7 atoms of O, appropriate artificial species might be



Sample case 3, Section 8.3, is setup to illustrate this situation.

*This is roughly the composition of XLDB with the solid Al_2O_3 removed.

**This composition is approximately that of carbon phenolic tape (MX4926).

6.5 THIRD TEMPERATURE RANGE

An optional third range for thermodynamic property curve fit constants can be used for those problems where the two standard ranges are not sufficient. These extra curve fit constants apply to low temperatures and are useful for extending the standard JANNAF curve fits to temperature less than 300°K. When the curve fit constants are determined care should be taken to insure that the specific heat, enthalpy, and entropy are continuous at the temperature that separates the lower range from the mid-range.

6.6 SELECTION OF AXIAL SOLUTION STATIONS

The choice of the location of the first solution station ($S(1)$, Group 3) and how far to step in the axial direction between solution stations is cause for some concern. Although there is no rigorous procedure for choosing the solution stations, there are some general guidelines that should be helpful.

As a rule of thumb the value of $S(1)$ should be selected to represent the physical distance along the wall upstream of the first solution station. (This number should not be zero.) Difficulty in getting convergence for the first station may be a result of $S(1)$ being too large. $S(1)$ can be reduced or the procedure described in Section 5.2 may be used. The axial step to the next solution station should no more than double the value of S . This step size is subject to the number of solution stations desired and the considerations discussed in the following paragraphs.

In general there are three features of the flow which influence the choice of solution stations.

- Discontinuities in geometry
- Discontinuities in wall conditions (ex. start of blowing or step change temperature)
- Pressure distribution.

All of these features contribute to the streamwise derivative terms ($\partial/\partial \ln \xi$) in the conservation equations discussed in Sections 2 and 3. These terms can become large and dominate the equations by two mechanisms. The first is the result of large changes in the physical quantity and is a natural part of the physics of the problem. The second is a result of the numerics and the computer being used in that $\partial \ln \xi$ is computed from $\ln \xi_i - \ln \xi_{i-1}$ (see Equation (3-36)). If ξ_i and ξ_{i-1} are too close together the differences in the logs may get excessively small or exceed the machine limits thereby resulting in large terms $\partial/\partial \ln \xi$, which inhibit convergence. Both must be considered. In regions of rapid physical change small steps should be taken so that the solution does not change drastically from station to station; however, if the steps are too small numerical problems may arise.

Discontinuities in geometry and wall conditions can be treated in the same manner. Solution stations should be placed on either side of the discontinuity and fairly close together. The change in conditions is considered to be spread over the distance between the two stations. If three-point differencing is being used ($KR(3) = 2$) both of these stations should be identified as discontinuities. (See Section 5, Group 3, Card set 2.) This helps to confine the effects of the discontinuity.

The selection of the solution stations with respect to the pressure distribution influences the solution through the calculation of the streamwise derivatives of the pressure and the free stream velocity. (Both of these terms appear in the momentum equation.) The difficulty arises from the method of calculating these gradients. There are three methods of calculating these derivatives in addition to directly inputting them.

The first method is preferred when a large number of pressure and velocity points are available as, for example, is the case with TDK output. For $IP \neq 0$ (see Section 5, Namelist \$INPUT) the gradients are calculated from linear averaging of the straight line slopes to adjacent points. The solution stations should then be selected from the set of TDK points such that the linear approximation is valid. This can be easily done by examination of a graph of the pressure versus axial position.

The other two methods are used when $IP = 0$. In this case the gradients are calculated from the set of pressure values at only those points used as BLIMP solution stations. The gradients can be calculated by either linear or quadratic methods.

Use of the linear option [$KR(3) = 3, 4, \text{ or } 5$] is less likely to lead to trouble, but is also considerably less accurate in highly nonlinear regions. Derivatives at a station are computed as the average of the linear slopes to one station forward and to one station backward (Figure 6-1).

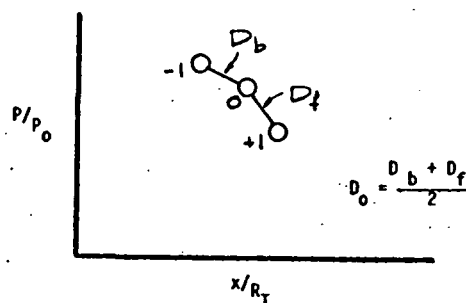


Figure 6-1. Linear derivative.

The quadratic option [$KR(3) = 0, 1, \text{ or } 2$] is more accurate but can give erroneous results, particularly in regions of large curvature. The derivative at a

station is the weighted average of the derivative calculated from a three-point backward quadratic, a three-point centered quadratic, and a three-point forward quadratic (Figure 6-2). The derivative of each quadratic is

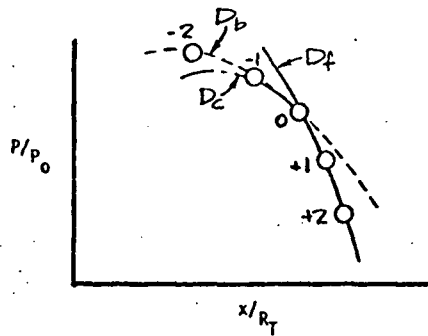


Figure 6-2: Quadratic derivative.

evaluated at the station in question (0 in Figure 6-2) and the derivative at the station calculated from

$$D_0 = \frac{D_b + 2D_c + D_f}{4}$$

In regions of large curvature the forward or backward quadratic can be in error as shown by the example below.

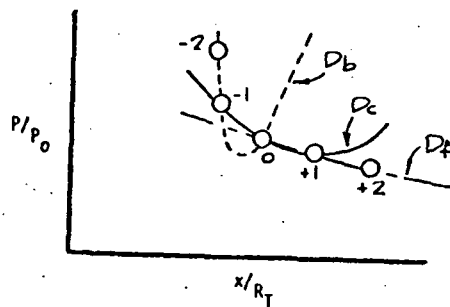


Figure 6-3. Quadratic derivative with error.

In this case the large positive derivative from D_b would outweigh the contributions from D_f and D_c and lead to errors.

As a guide to the user, the following suggestions are offered.

1. Select the distribution of solution stations by referring to a graph of P/P_0 vs. X/R_T (or S/R_T). (This is in addition to discontinuity considerations.)
2. Decrease the interval between points in regions of large $|dP/dx|$ and large $|d^2P/dx^2|$.
3. Check the output values of β_v (the streamwise derivative of edge velocity). For rocket nozzles it is expected that $du/dx > 0$, therefore, it is negative values of β_v where positive values are expected that indicate a poor selection of solution stations. Also, β_v (and β_p) should be smoothly varying.
4. Use the linear option [$KR(3) = 3, 4, \text{ or } 5$] and select the solution stations so that the average linear slope is a good approximation to the slope of the dP/dx curve.

It should be stressed that accurate evaluation of the pressure gradient is of utmost importance to reliable solutions, and every effort should be made for a proper choice of the solution stations.

6.7 NODAL DISTRIBUTION AND REFIT

A suggested distribution of nodes for both laminar and turbulent flow is given in Section 5, Group 4. These distributions should be adequate for most problems, particularly when the REFIT option is used. The key parameters for the nodal distribution are CBAR, KAPPA, and the ratio $ETA(KAPPA)/ETA(ETA)$. The selection of KAPPA establishes the node that will be used to stretch the boundary layer profile to accommodate growth of the boundary layer. The velocity ratio at the KAPPA node is fixed by CBAR. The ratio $ETA(KAPPA)/ETA(ETA)$ determines how thick the boundary layer can be relative to the location of the KAPPA node. All other node locations can be adjusted by the REFIT option.

6.7.1 REFIT

An option has been developed for the BLIMP-J code which will change the values of the independent variable, η , ($ETA(I)$, the nodal distribution across the boundary layer) during code execution. The purpose of this option is to provide a means for maintaining an optimum nodal distribution for problems which include nonsimilar effects such as transition to turbulence, blowing, pressure gradients, long streamwise running lengths, etc. This readjustment is accomplished while preserving the

fundamental characteristics of each profile, namely, basic profile shape, wall and edge derivatives, and integral properties. Potentially a number of bases may be identified for selecting nodal distributions and for making decisions relative to changing the existing distribution, e.g., mapping of any one of the velocity, temperature, and specie profiles. However, since adequate mapping of the velocity profile is the most commonly encountered problem, a selection criterion based on this parameter has been implemented, and the identification, evaluation and implementation of any other possible criteria has not been pursued at this time. Initially the selection criterion has been based upon maintaining a desired (specified) velocity ratio distribution across the boundary layer. For nonsimilar turbulent flows, for example, the nodal distribution will change as a function of distance to account for the changes in velocity profile shape as the turbulent layer develops. The decision to refit is made following a converged solution and is based on whether or not the newly calculated velocities vary by more than a selected ratio from the desired values.

The REFIT procedure is currently valid for all forms of curve fitting across the boundary layer (KR(10)), i.e., all quadratics, quadratics with a final cubic and all cubics. Finally, as a result of the basic features of the REFIT option, it is possible to change the number of nodes used to describe the boundary layer. This latter capability has been programmed only for the case of transition from laminar to turbulent flow, as a means for eliminating the unnecessary and expensive nodes from laminar calculations. As such, this option is limited to this application; however, potentially it may be programmed for more general application. The REFIT option is limited to a maximum of 15 nodes; however, as might be anticipated, the ability to maintain a more optimum distribution of nodes makes it possible to solve most problems using fewer nodes than normally required without REFIT. For example, for some long streamwise length, turbulent flows, it is either very difficult or impossible to estimate in advance the best distribution for the entire length using all 15 nodes. With REFIT, it is possible to achieve good results with normal selection of desired velocity ratios using 12 nodes. Since solution times vary roughly as the number of nodes squared, this represents a saving of 40 percent in computer time, some of which is used in the refitting operation.

6.7.2 Basic REFIT Procedure

A description of the basic procedure is as follows. An input switch (KONRFT) is available to activate the REFIT option. If KONRFT is greater than 0, the REFIT option will be used. In this event, a set of desired values of the velocity ratio, u/u_e (F2FIX(1)) must be read in. These represent the desired, fixed values of u/u_e as a function of node number. This set of values is selected based on such considerations as keeping nodes within the laminar sublayer for turbulent flows

($u/u_e < \sim 0.05$); maintaining good spacing in the middle velocity region where integral quantities are strongly affected; and, finally, defining and maintaining good spacing at the outer edge to prevent overshoot of the profile. (Note that this latter goal is one of the advantages of the REFIT method since the nodes between the fixed node (KAPPA) and outer nodes are tied to desired velocity ratios which are less than 1.0).

The capability to change the number of nodes (NETA) across the boundary is also available. Currently this is associated directly with the onset of transition from laminar to turbulent flow. The switch KTURB determines if this sub-option is to be employed. For KTURB = 1 the number of nodes will be changed following the first turbulent solution for transition based on Re_θ , momentum thickness Reynolds number. The BLIMP code assumes a finite transitional length which is equal to the streamwise length prior to onset of transition. Consequently, the first turbulent solution is still effectively a laminar solution because the transitional factor applied to the eddy viscosity is equal to zero. Thus the laminar nodal distribution is adequate for the "turbulent" part of the solution at the first turbulent station.

Following a converged solution (at the end of OUTPUT), the REFIT is called if KONRFT > 0 and either IS = 1, the ratio criterion is exceeded, or the number of nodes is being changed. At this point, the η values and all the primary boundary layer variables and their derivatives are passed to the main subroutine (REFIT) of the REFIT option. This package first takes the existing distribution $u/u_e(I)$, consisting of ETA(I), F(2,I) and derivatives, generates the quadratic and cubic curve fit coefficients consistent with the curve fit option used in BLIMP (KR(10)) and then solves for the new locations of the ETA nodes based on the F2FIX values. Additional points are generated in each new polynomial segment (NPOINT per segment). These data points, subject to the following constraints, are created in the subroutine POINTS.

1. Connecting curves must have equal function values at the new node.
2. Connecting curves must have equal first derivatives (spline fit) at the new node.
3. Connecting curves must have equal second derivatives at the new nodes if the curve option is all cubics, KR(10) = 0. The function value and the η value must be maintained at the first and last nodes.
4. The first derivative value must be maintained at the first and last node (except for all quadratics, KR(10) = 2, for which the outer derivative must float).
5. The function value and the η value must be maintained at the KAPPA node.

These data points and constraints which define the old curve together with the new η values are then operated on by a series of subroutines (FISLEQ, FILQ3, FINEQ, and FILQ5) which perform a least squares curve fit. The results of this operation are returned to BLIMP as the new values of $F(2,I)$, $F(3,I)$ and $F(4,I)$ at the new values of $ETA(I)$. This process has been selected specifically to preserve the important characteristics of the profile, namely the derivatives at the wall and all integral quantities.

In identical manner, the other dependent variables, i.e., $G(1,I)$ and $SP(1,I,K)$, are adjusted to the new values of $ETA(I)$. Note that the redistribution of η is based on the input u/u_e selection criterion; once this has been completed, all other variables are adjusted to this new distribution. This is the only selection criterion considered at this stage of development.

6.8 RESTART/FIRST GUESS OPTION

An option [$KR(2) = 3$] is available for restarting BLIMP at any solution station. This option is useful for continuing a solution which has been stopped during execution. (For example, exceeding the time limit or faulty data downstream of the selected station.) RESTART should be used with care since there is some loss of accuracy at the restart station. It is important that the restart station be a valid solution station since the input is accepted as the solution. The card punch options ($KR(8) = 1,2$) should not be used with RESTART if the restart station is downstream of the throat since the normalizing factor, throat radius, would not be corrected for displacement thickness.

A potential problem associated with the RESTART option involves turbulent transition. This version of BLIMP-J has a transition length for the development of a fully turbulent boundary layer. This length is equal to the length upstream of the station at which the turbulent transition criterion (Re_θ) is exceeded. A RESTART should not be made at a station in this region. For restarting in the fully turbulent region the transition Reynolds number should be input as zero.

The option for inputting a first guess at the first station ($KR(2) = 1$) is useful for starting those problems which have well developed turbulent profiles. The built-in guess can lead to an excessive number of iterations for such cases. This option is also useful for starting those problems which have a large degree of nonsimilarity in streamwise solutions. However, it is very difficult to provide accurate profile information without careful calculations or output of a previous solution. A reasonable first guess frequently can be obtained from the output of a previous, similar problem (see Sample case 6.1).

The additional input for RESTART or FIRST GUESS is described in Group 9 of the input instructions. For RESTART this information can be obtained from the output at the restart station. If the restart station is also a refit station, the values of ETA and the nodal distribution of $(F(2,I), G(1,I)$ and $SP(1,I,K)$ are those of the REFIT output.* The input ETA values must agree with those used for the solution station.

6.9 TURBULENT TRANSITION

Transition to turbulent flow can occur in two ways (see Input Instructions, Group 8).

- The momentum thickness Reynolds number exceeds an input critical value
- The station number equals a prescribed value for transition

In the first case a transition length for full turbulence is used (see Section 2), whereas, in the second case full turbulence occurs immediately.

It is not possible to give an appropriate, universal transition value of momentum thickness Reynolds number for compressible, highly accelerating flows. A flat plate zero pressure gradient value of $Re_\theta = 360$ serves as a nominal guess. It is known that for accelerating flows the transition value increases. The value selected will depend on the particular problem under consideration.

6.10 BLIMP-J INTERFACE WITH OTHER JANNAF PROGRAMS

Special input and output features have been added to the BLIMP-J program to make interface with other JANNAF programs used in the rocket engine performance and evaluation procedure more convenient for the user. Part of the required input to BLIMP is the edge pressure distribution and the coordinate pair (x,r) description of the nozzle contour. These quantities can be directly obtained as part of the punched card output of TDK in the form of a namelist of values PITAB (pressure), XITAB (x coordinate), and YITAB (nozzle radius). This output typically starts near the nozzle throat and consists of several hundred values for each variable. Similar information for the region upstream of the throat can be obtained from ODK. The quantities can then be used directly as input to BLIMP in namelist \$INPUT, which is described in Section 5.2. BLIMP also uses the same form of the JANNAF thermochemical data as TDK, thus the same species decks can be used for both programs (see Section 5.2, Group 13).

The BLIMP-J program will also punch a corrected body contour (XITAB, YITAB) in the namelist form suitable for direct input to TDK. (The corrected body contour

* The quantities used for RESTART input are marked by † on the Sample case 1 output.

option is described in Section 4.2 in subroutine ROCOUT.) This corrected contour is useful if it is desired to rerun TDK using the inviscid flow field contour (body contour minus the body displacement thickness as calculated by BLIMP-J) or if it is desired to have a new body contour (inviscid flow contour plus the body displacement thickness) for other purposes.

6.11 POTENTIAL PROBLEM AREAS

The integral matrix procedure which is used to solve the boundary layer equations uses general Newton-Raphson iteration, as does the chemistry solution procedure. In this iteration process the derivatives of all equations with respect to the primary dependent variables are employed to drive the errors toward zero. The boundary layer equations converge very rapidly (3 or 4 iterations) when chemistry is not taken into account but the chemistry equations themselves are very nonlinear and, furthermore, can cause the boundary layer equations to become very nonlinear. Therefore, it has been necessary to develop extensive convergence damping procedures for both the chemistry and boundary layer iteration procedures. These have proven generally to be quite satisfactory, but difficulties are sometimes encountered for very severe problems. The types of problems which can occur, the symptoms of these problems, and procedures for coping with the problems are discussed in this section. The subject of possible program errors and debug output useful for tracing any such errors is discussed later in this section.

The most common causes of difficulty are errors in input, improper selection of input, and chemistry nonconvergences. Errors in input are the most frequent and include improper format, omitted data, extra data and mispunched cards. As a general rule, input quantities should be verified with the program output whenever possible. Most of the problems with selection of the input are associated with the location of the solution station and the nodal distribution which have been discussed in Sections 6.6 and 6.7, respectively. The location of the solution stations is important primarily in regions where the degree of nonsimilarity is high; for example, large β or rapid changes in wall conditions. Often a slight change in solution station location will alleviate the problem. Errors of this type frequently manifest themselves as nonconvergent solutions (50 iterations). Characteristically the DAMP term is much less than one or fluctuates rapidly, iterations are skipped, or the iteration count may recycle from 50 to 30 and then procede to 50 before stopping. If the solution goes 50 iterations and has not converged a relaxed convergence test is applied. If this test is passed the solution procedure continues, often without further problems.

An unsuccessful solution which manifests itself as a nonconvergent chemistry is often not the result of an inadequacy or programming error in the chemistry routines (EQUIL and its subroutines) but is traceable to one of the following: (1) an excursion has occurred during the boundary layer iteration such that the chemistry

routines have been called upon to solve an impossible problem, or (2) a bad chemistry data deck has been employed. The latter could be bad thermochemical property data (e.g., curve fits which produce negative C_p) or a poor choice of species (e.g., omission of a species important to the solution). These types of considerations should be investigated first if a nonconvergent chemistry occurs (see Section 7.6 for chemistry debug output).

On occasion when the equations are particularly nonlinear, the chemistry iteration can get temporarily trapped away from the solution. A very elaborate rescue procedure ensues which usually overcomes the difficulty but, sometimes, not within the allowed number of chemistry iterations. If a chemistry solution is nearly converged, recovery may be possible. For this reason, the boundary layer iteration is allowed to proceed with a notation in the output that a nonconvergent chemistry has occurred. If no nonconvergent chemistries occur in the iteration just preceding a converged boundary layer solution, any prior chemistry nonconvergences can be disregarded. On the other hand, if a chemistry solution is far from convergent, it may produce a fatal error in a subsequent chemistry or boundary layer iteration. In any event a STOP is encountered after 20 nonconvergent chemistry solutions accumulate in the current case.

If the user is considering unequal diffusion coefficients, he should then revert to assumed equal diffusion coefficients since the derivatives used in the convergence process (these do not affect the final answer as the solution converges) are less exact in unequal diffusion problems. Also, one could set up a sequence of subcases leading up to the problem of actual interest.

It should be emphasized that the convergence procedures employed in the chemistry and boundary layer iterations are nearly 100 percent reliable for most problems and get into difficulties only occasionally and then only for problems with massive blowing (say where the boundary layer gas in the vicinity of the wall consists of about 99 percent or more of gas injected from the wall), for large nonsimilarity effects, and for unequal diffusion problems where the unequal diffusion effects are very strong.

It is, of course, possible that a bug in the program has actually caused a problem. It is thus pertinent to review the operational status of the program. The BLIMP program of which BLIMP-J is an extension has been used extensively over the last 7 years. During this time the number of boundary layer solutions which have been obtained probably exceeds 3000, while the number of chemistry solutions (required at each boundary layer nodal point and for each boundary layer iteration) is probably well in excess of 300,000. In view of the size of the program and its enormous number of options, however, it is possible that some errors may still exist for some combinations of these options. For this reason an elaborate system of debug

write statements has been retained in the program. Debug output is obtained by setting KR(15) through KR(20) to nonzero values. The output obtained with the various KR options is summarized in Section 4. The extremely ambitious and sophisticated user should be able to track down any such error with the use of this debug output and the information presented in this manual.

SECTION 7

OUTPUT

This section contains a discussion of the normal mode output for the BLIMP-J program and brief comments on the debug output. Much of the output is self-explanatory; therefore, only those terms needing further explanation or definition will be considered. The units for output are the same as those used for input.

Standard abbreviations are used in most cases with some exceptions where space was limited. The most notable exceptions are:

B — BTU — British thermal unit
LB — LBM — pounds mass
F — FT — feet

7.1 OUTPUT SUMMARY

In general the output consists of the following sections:

- Program heading, control options, input stagnation conditions, and turbulent parameters
- Edge gas composition and the input thermodynamic curve fit data
- A list of the elements, the associated base species, and transport property calculation procedures
- The edge expansion thermodynamic state for the stagnation conditions and each solution station
- Summary table of wall and edge conditions
- Boundary layer solution, station by station, nodal information in detail, and REFIT output
- Corrected contour summary for use in connection with TDK program
- Plot output.

It should be noted that the entire input data is not printed as part of the output. It is recommended that the input be listed for use in identifying errors and preserving the input details for later reference. The first three of the above need no further explanation. They are clearly illustrated by the sample problem output in Section 8.

7.2 EDGE AND WALL CONDITIONS

7.2.1 Edge Expansion Thermodynamic State

Most of the information presented in this output is self-explanatory, however, the following definitions are given for the purposes of clarity.

- CP-FROZEN -- Specific heat calculated from the mass fraction and specific heat of each species at the specified temperature

$$CP-FROZEN = \sum_i K_i C_{p_i}$$

- CP-EQUIL -- Specific heat calculated from $\partial h / \partial T|_p$ and allowing for changes in composition

$$C_{p_{EQUIL}} = \sum_i K_i C_{p_i} + \sum_i h_i \left. \frac{\partial K_i}{\partial T} \right|_p$$

- GAMMA = $\left(\frac{\partial \ln P}{\partial \ln \rho} \right)_s$

- MACH NUMBER = $U_e / \sqrt{(\partial P / \partial \rho)_s}$

7.2.2 Summary Table of Wall and Edge Conditions

The following quantities appear in the summary table and may need some explanation:

- XI -- The normalized streamwise coordinate defined by Equation (3-6)

$$\xi = \int_0^s \rho_1 u_1 \mu_1 r_0^2 K ds$$

- BETAV -- Defined by Equation (3-12)

$$\beta_v = 2 \frac{\partial \ln u_1}{\partial \ln \xi}$$

- BETAP -- Defined by Equation (3-13)

$$\beta_p = - \frac{2}{\rho_1 u_1^2} \frac{\partial p}{\partial \ln \xi}$$

- COMP FLUX. — Input wall flux of boundary layer edge gas, pyrolysis gas, and char gas for KR(9) = 0, 1 or 2.

7.3 BOUNDARY LAYER OUTPUT AT EACH STATION

For each solution station four groups of information are output:

- Iteration summary
- Miscellaneous output — integral properties, wall conditions, transfer coefficients, etc.
- Nodal information
- Refit information

7.3.1 Iteration Information

The iteration information shows the progression toward a solution. Most of this information is useful in locating convergence errors. For normal solutions the value of ALPH (the coordinate stretching parameter, α_H) and FPPW (the normalized velocity gradient at the wall) should stabilize before convergence. The DAMP term reflects the allowable correction for each iteration and should rapidly approach a value of 1.0. Very small or zero values of DAMP indicate that the error in the solution is very large and that convergence may not occur.

As part of the iteration information the maximum linear error, the maximum nonlinear error and the equation in which it occurs for each set of conservation equations (momentum, energy, and species), and the number of nonconvergent chemistry solutions are printed. In Section 3 the solution technique was discussed and it was stated that the errors were to be driven to zero. The actual convergence test requires that the errors be reduced to less than some relatively small amount. The convergence test is given below.

$$EL_{MAX} + ENL_{MAX} \leq \alpha_H \eta_{NETA} 4 \times 10^{-5} \quad (7-1)$$

where EL_{MAX} is the absolute value of the maximum linear error and ENL_{MAX} is given by

$$ENL_{MAX} = \max \left(\frac{10E_M}{\max(1, |\beta_p|) \alpha_H}, \frac{E_E}{\max(1000, |H_{T_e} - H_{T_w}|)}, E_{SP} \right) / 10 \quad (7-2)$$

where E_M , E_E , and E_{Sp} are the absolute values of the maximum nonlinear errors in the set of momentum, energy, and species equations, respectively. The equation numbers, printed just to the left of the maximum error, correspond to the equations as shown below.

Momentum Equations

<u>Number</u>	<u>Equation</u>
1	surface equation
2	α_H constraint, Equation (3-84)
$i + 3$	momentum equation between the i and $i-1$ nodes, Equation (3-42)

Energy and Species Equations

<u>Number</u>	<u>Equation</u>
1	surface equation
i	conservation equation between the i and $i-1$ nodes, Equation (3-43) or (3-44)

The last integer to the right of the iteration printout is the number of non-convergent solutions. This number is reset to zero after each converged boundary layer solution. A maximum of 20 nonconvergences is allowed before the program is terminated.

7.3.2 Miscellaneous Output

The following definitions will be helpful in understanding this section of the output:

- ALPHA — Coordinate stretching parameter. $ALPHA(\alpha_H)$, $ETA(\eta)$, and y (the physical coordinate) are related through

$$\eta = \frac{u_1}{\alpha\sqrt{2\xi}} \int_0^y r^K \rho dy$$

- HEAT FLUX-DIFFUSIONAL — heat flux to the wall due to diffusion, mass diffusion included ($-\dot{q}_{aw}$ in Equations (2-24) and (2-86)). For options KR(9) = 3, 4, or 7 this term satisfies the energy balance equation

$$\dot{q}_{aw} + RERAD + (\rho v)_w h_w - \dot{m}_c h_c^0 - \dot{m}_g h_g^0 - RADFL(1) \cdot RADR(IS) = 0$$

where \dot{m}_c and \dot{m}_g are output as char and pyrolysis gas rates and h_c^0 and h_g^0 are input in Group 6.

- HEAT FLUX-TOT ENTH - net enthalpy flux to wall; diffusional heat flux less the energy convected away from the wall by blowing ($= -\dot{q}_{aw} - (\rho v)_w h_w^0$)
- RERAD - reradiated heat flux, zero except for energy balance problems where $\epsilon > 0$ ($\epsilon \sigma T_w^4$).
- QCOND $= k \frac{dT}{dy}|_{wall}$
- MECHANICAL REMOVAL - computed as the difference between the total gas flux and the sum of the pyrolysis and char fluxes
- Blowing parameters defined by

$$B'_g = \frac{\dot{m}_g}{\rho_1 u_1 St}$$

where \dot{m}_g is the mass flux of pyrolysis gas, char gas, or total gas at the wall

- Transfer coefficients

$$C_{f/2} = \frac{\tau_w}{(\rho_1 u_1) u}$$

$$St = \frac{\text{total diffusional heat flux}}{\rho_1 u_1 (G_e - G_w)}$$

$$CM_j = \frac{\text{mass diffusive flux } j}{\rho_1 u_1 (K_{j_e} - K_{j_w})}$$

where K_j is the mass fraction of element j given by

$$K_j = \sum_i C_{ij} \tilde{K}_i$$

where C_{ij} is the mass fraction of element j in base species i .

- Momentum thickness (θ), enthalpy thickness (λ), and mass thickness

$$\text{thickness} = \int_w^e \frac{\rho_e u_e}{\rho_e u_e} \frac{(P_e - P)}{(P_e - P_w)} dy$$

where P is either, u , G , or \tilde{K}_i .

- Displacement thickness = $\int_w^e \left(1 - \frac{\rho_e u_e}{\rho_e u_e}\right) dy$

- Effective body displacement — same as displacement thickness for no blowing cases. In the case of blowing, this parameter gives the inviscid flow field displacement. Given by

$$\delta_B^* = y_e - \frac{\sqrt{2\xi} f_e}{\rho_e u_e r_o^\kappa}$$

- TOTAL HEAT TO WALL — This represents the net heat that is absorbed by the walls and must be removed by some sort of cooling or retained by the walls.

$$Q_w = \int_{s_0}^s L \dot{q} ds$$

$$\text{where } L = \begin{cases} 2\pi r & \text{axisymmetric flow} \\ 1 & \text{2-D flow} \end{cases}$$

$$\dot{q} = \begin{cases} \text{HEAT FLUX - TOT ENTH} & \text{for KR(9) = 0,1,2} \\ -\text{RADFL(1)} * \text{RADR(IS)} & \text{for KR(9) = 3,4,7} \\ & \text{and RADFL(1) *} \\ & \text{RADR(IS).LT.0} \end{cases}$$

- THRUST LOSS (ΔF)

$$\Delta F = L \rho_e u_e^2 \theta \cos \phi \left(1 - \frac{p \delta_B^*}{\theta \rho_e u_e^2} \right)$$

where L defined as before. This represents the thrust loss due to boundary layer effects. All of the terms in the equation above are taken from the BLIMP solution at the station of interest.

- TOTAL WALL AREA — The wall area calculation is an approximation to the actual wall area and is based on trapezoidal integration between BLIMP solution stations of

$$A = \int_{s_0}^s L ds$$

where L has been previously defined.

- ACCELERATION PARAMETER-K — This parameter gives an indication of possible laminarization of a turbulent flow. Values of K exceeding 3×10^{-6} indicate possible laminarization.

$$K = \frac{v_e}{u_e^2} \frac{du_e}{ds}$$

- INVISCID MASS IN BL — This represents the portion of the mass flux in the boundary layer that was originally part of the inviscid flow. Thus it represents the mass flux between the zero streamline and the boundary layer edge

$$\dot{m}_{INV} = L \sqrt{2\xi} f_e$$

- TOTAL MASS IN BL — This is the total mass flux contained between the wall and the boundary layer edge. In the case of no mass injection it is the same as the inviscid mass flux given above

$$\dot{m}_{TOTAL} = L \sqrt{2\xi} (f_e - f_w)$$

7.3.3 Nodal Information

The values of the primary variables, their derivatives, and several derived quantities are given at each node. First derivatives are denoted by P and second derivatives by PP. (For example FPP is the second derivative of F with respect to $\alpha_H \eta$.) All derivatives are with respect to $\alpha_H \eta$. F is the stream function and G is the total enthalpy. The thermodynamic Prandtl number is based on frozen specific heat. The modified Schmidt number is a Schmidt number based on the self-diffusion coefficient for a fictitious species representative of the system as a whole. The term $RHOSQ*EPS/RHO*MU$ is the ratio of the local turbulent viscosity to the molecular viscosity at the boundary layer edge.

7.3.4 REFIT Information

If the REFIT option is called the new values of ETA and the primary variables are printed. This information is particularly useful for RESTART input.

7.4 CORRECTED CONTOUR OUTPUT

The option $KR(8) \neq 0$ causes printout and punch of contours corrected for the effects of effective body displacement. This option is explained in detail in Section 4.2 in the discussion of subroutine B11B. The output associated with this option is self-explanatory. If the contour input to BLIMP is a body contour, the corresponding inviscid flow contour (which can be used in TDK) is printed (and punched if requested). Similarly, if the contour input to BLIMP is the desired inviscid contour then the new body contour is printed.

7.5 PLOT OUTPUT

An option is available to enable a plot file to be written to a specified unit. (This unit is identified as KPLT and has been set as $KPLT = 18$ in B02A.) The file is written as a series of records by unformatted write statements. The source and content of each record are listed below. This output can be selectively used as input for a plotting routine. All units are those specified by the $KR(13)$ option.

Record 1 (B07A)

Write list*: stagnation pressure, stagnation enthalpy, number of stations, $s(40)$, $\xi(40)$, $x(40)$, $R(40)$, $P(40)$, $U_e(40)$, $B_p(40)$, $B_v(40)$

Record 2,3,... NS-1 (B11A) — one for each solution station

Write list*: station number, number of nodes, net enthalpy flux, T_w , $(\rho v)_w$, $C_f/2$, St , B_{TOTAL} , θ , δ_B^* , total heat to the wall,

*The write list is exactly as it appears in the program except that variable names and symbols have been used in lieu of Fortran variables. The numbers in parentheses are the variable dimensions.

thrust loss, total wall area, acceleration parameter, inviscid flow in the boundary layer, total mass flow in the boundary layer, $y(15) u/u_e(15)$, static enthalpy (15), $T(15)$, $M(15)$, $\rho(15)$, $\mu(15)$, $C_p(15)$, $\rho^2 \epsilon / \rho_e \mu_e(15)$.

7.6 DEBUG OUTPUT

There is extensive debug output which can be obtained by proper choice of the KR(15) through KR(20) options (see Section 5). However, most of this output is useful only to the very sophisticated user. There are two parts which may be useful to the average user. The first is really not debug output but is the regular program output for a converged solution, output after each iteration (KR(4) = 1). This can be very useful to help locate where the source of trouble is. The second output is for nonconvergent chemistry (KR(18) > 0). This is helpful in locating bad values of C_p or irregular species concentrations. This output contains the complete thermodynamic output normally given with the edge expansion and some additional output for each species, the most important of which is C_p . An example of this output (Figure 7-1) and an explanation of the terms, which will help to clarify the debug output, are given below.

PIVOT/ROW/etc. — This output appears when the matrix for the chemistry problem is singular. (The numbers that follow the test give the location of the singularity.)

ISS — station number

ITEM = 1

II — node number

MIT — boundary layer iteration number

ITS — chemistry iteration number (numbers larger than 50 appear when a fatal error in problem set-up has resulted in an impossible problem which has been caused to exist from the chemistry solution by artificially setting ITS.GT.50)

IQQ — -1 for nonconvergent, -2 for debug output before nonconvergence

KR(6) — -1 for gas phase problem, 0 or +1 for surface balance problem

HIP,SIP,TT(II) — enthalpy, entropy, and temperature for this iteration in cal, gm, °K

ALP(I) — mass fraction of element I

LEF(I) — described in Fortran Variables List

FR(I,II) — mole fraction of species I at node II

PIVOT ROW/COL/RES.RATIO 1/ 1/ .00 ,
PIVOT ROW/COL/RES.RATIO 1/ 1/ .00 ,

-----FOLLOWING OUTPUT NON-CONVERGENT-----

ISS,ITEM,I,ITEMS,ITS,LOG,KR(6),HIP,SIP,IT(II)/ALP(I)/LEF(I)/FR(I,II)

1 1 2 1 1000 -1 -1 1.58801+02 3.31568-01 0.00000 0.00000 0.00000 0.00000

-3.6380-12 1.0200-03 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000
3 3 3 0 0 0 0 0 0 0 0 0 0
0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000
0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000
0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000

((C(I,J),J=1, 6),(D(J),J=1, 6),I=1, 6) BEFORE REFRAY

L(I),I=1, 6 1 2 3 4 5 6
.000 .000 .000 .000 .000 .000 .862+02
.000 .000 .460+00 .844+00 .123+02 .280+01 .000
.000 .198-11 .318-01 .281-02 -.172+00 -.558+00 .219-46
.000 -.554-03 .281-02 .472-01 -.304+00 -.991+00 .000
.000 -.172+00 -.304+00 .311+02 .139+02 .000
.000 .000 -.558+00 -.991+00 .139+02 .572+02 .102-02

PIVOT ROW/COL/RES.RATIO 1/ 1/ .00 ,

CP-FROZEN CP-EQUIL GAMMA

J/KG-K J/KG-K

.00000 .81734+00 -.84019-06

TEMP = 5119.0300 DEG-K PRES = 6.438+06 N/M2 MDL WT = .0854559

ENTHALPY = .0000000 J/KG ENTROPY = -.11113+07 J/KG-K

DENSITY = .129244-02 KG/M3

SPECIES	PAR.PRES.	D-LOG-PP	LOG-PP	LOG-KP	FLAG	ERROR	CP
WALL GAS	.00000	.22019+08	-.15204+04	.00000	-4	-.45988+00	.00000
WALL GAS	.00000	-.27510+08	-.15099+04	.00000	-4	-.84379+00	.00000
H2	.16221+01	-.12261+07	.48373+00	.00000	0	-.12330+02	.00000
CO	.84766+01	-.13702+03	.21373+01	.00000	0	-.28032+01	.00000
C(S)	.00000	.00000	.00000	.00000	-4	.00000	.00000
C	.16232+01	.28111+07	.48442+00	.00000	0	-.24569+02	.00000
C2	.16221+01	.40233+07	.48374+00	.00000	0	-.48653+02	.00000
C3	.16221+01	.47778+07	.48373+00	.00000	0	-.72737+02	.00000
C4	.16221+01	.62102+07	.48373+00	.00000	0	-.96821+02	.00000
C5	.16221+01	.71735+07	.48373+00	.00000	0	-.12091+03	.00000
CH3	.16221+01	-.56302+06	.48373+00	.00000	0	-.23843+02	.00000
CH4	.16221+01	-.17412+07	.48373+00	.00000	0	-.23601+02	.00000
C2H	.16221+01	.24809+07	.48373+00	.00000	0	-.48411+02	.00000
C2H2	.16221+01	.12500+07	.48373+00	.00000	0	-.48169+02	.00000
C2H4	.16221+01	-.46241+06	.48373+00	.00000	0	-.47685+02	.00000
CO2	.16221+01	-.12753+07	.48373+00	.00000	0	-.27875+02	.00000
HCN	.16223+01	.66731+06	.48383+00	.00000	0	-.83544+02	.00000
H2O	.16221+01	-.24791+07	.48373+00	.00000	0	-.26222+02	.00000
H	.92446+01	-.70567+02	.22240+01	.00000	0	-.19822+01	.00000
HCO	.16223+01	-.36046+06	.48383+00	.00000	0	.1A954+01	.00000

Figure 7-1. Sample of nonconvergent chemistry debug output.

((C(I,J),etc. — This output comes from RERAY (B15B) and pertains to the matrix that is to be inverted.

FLAG — This is the variable IFC described in the Fortran Variables List.

PP — partial pressure

SECTION 8

SAMPLE CASES

8.1 SAMPLE CASE 1 — SPACE SHUTTLE MAIN ENGINE

This sample problem represents a typical problem for a liquid propellant rocket nozzle. The nozzle geometry, pressure distribution, fuel composition, and wall temperature are typical of the space shuttle main engine. The nozzle contour and pressure distribution input were provided from the output of a single zone TDK run. The pressure distribution and wall temperature are shown in Figure 8-1. The stagnation conditions are given below:

$$P_o = 2.0477 \times 10^7 \text{ N/m}^2$$

$$T_o = 3653^\circ\text{K} \quad (H_o = 6.9501 \times 10^5 \text{ J/kg})$$

$$MR = 6$$

The stations selected as solution stations are indicated on Figure 8-1. The stations marked with a D are to allow for the discontinuities in wall temperature. A first guess (KR(2) = 1 and Group 9) at the first solution station was made using the results of a previous problem at different conditions. This was done to reduce the number of iterations at the first station, where a well developed turbulent profile was expected. Maximum use of the namelist input was made, and the default values of many of the parameters of Groups 4 and 8 were used. (The Kendall model is the default turbulent model.) The unequal diffusion option (KR(14) = 1) was used and diffusion coefficients (F_i and G_i) were input (Group 12). (Reference 10 contains a discussion of how to compute diffusion coefficients.) Also, a corrected body contour (KR(8) = 3) was printed out.

A complete listing of the input and samples of the output are provided. (Run time on a Univac 1108, Exec 8 system was 260 system seconds.) It is worth noting that for this problem the use of unequal diffusion coefficients resulted in an approximately 20 percent increase in execution time and only a 1 to 3 percent change in the parameters of interest (heat flux, thrust loss, etc.). The laminar transport properties, viscosity, thermal conductivity, and Schmidt number, changed by 10 to 20 percent; however, this change was overshadowed by the turbulent transport mechanisms.

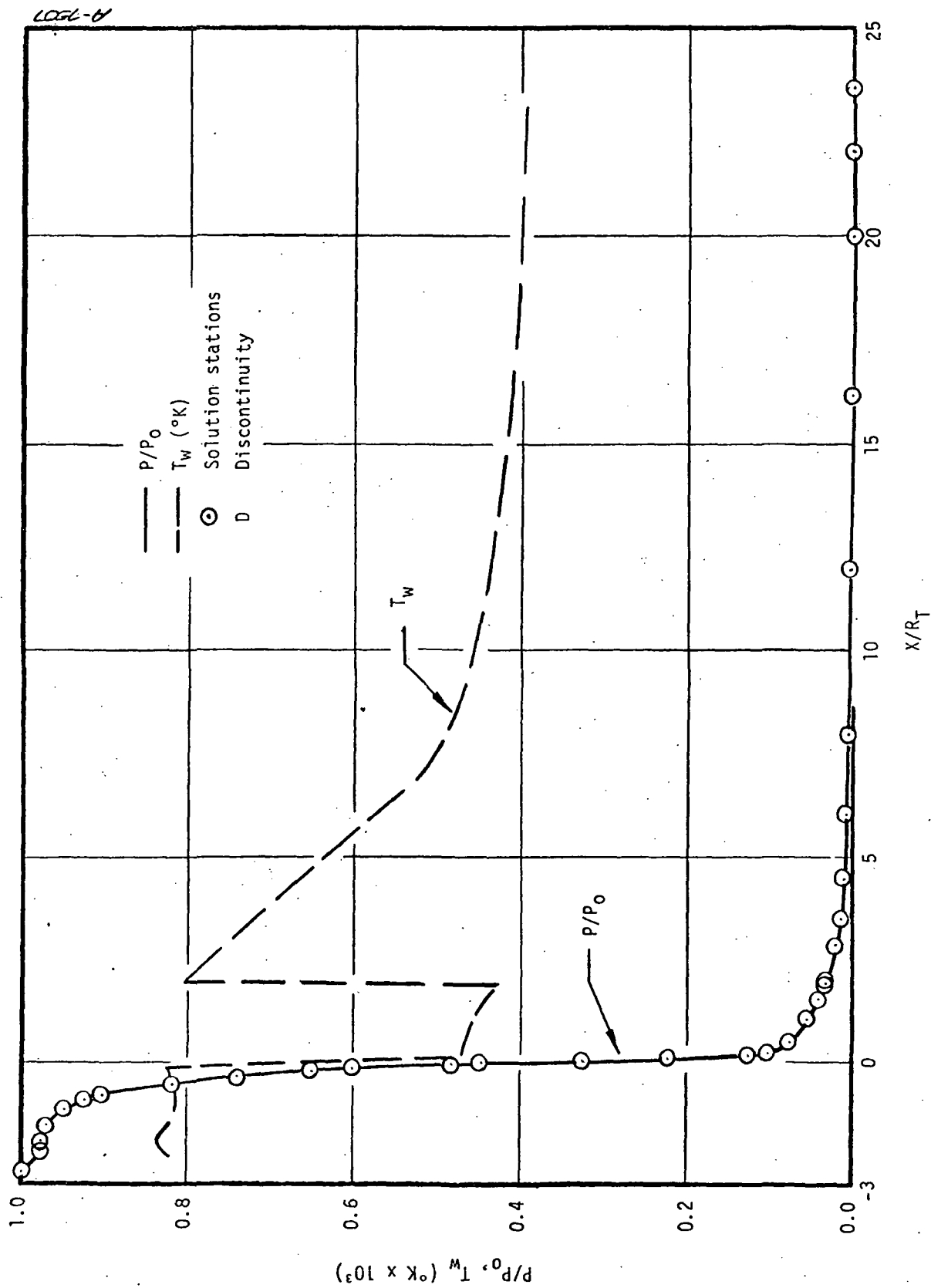
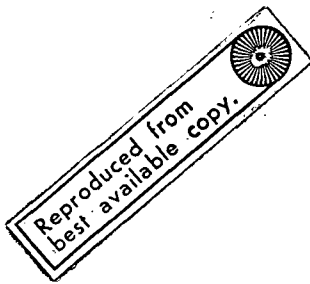


Figure 8-1. Pressure distribution and wall temperature, sample case 3,
 $(R_T = 0.130878 \text{ m}, P_0 = 2.0477 \times 10^7 \text{ N/m}^2)$



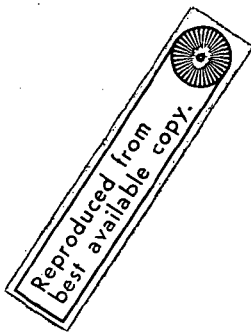
8.1.1 Sample Case 1, Input

1 3120062321020100000 SSNE=NPL (FIRST GUESS) SAMPLE CASE 1 01100 N
2 MISLIS , NS=31 , S(1)=1.04,
3 NSP=2 ,
4 NETA=12 , ETA=0.0 , 0.002003 , 0.006808 , 0.01557 , 0.02703 , 0.04335 ,
5 0.1465 , 0.4154 , 0.7219 , 1.0 , 1.203 , 2.5 ,
6 KONRT=1,
7 RT=0.130A785A,
8 PRT(1)=2.0477E+07,GF(1)=-0.9501E+05,
9 SEND
10 INPUT
11 N=393, NTH=31,
12 NS=2, 4, 10, 15, 18, 20, 24, 26, 28, 29, 30, 31, 3A, 47,
13 53, 55, 83, 140, 180, 211, 213, 265, 280, 293, 317, 334, 357, 373,
14 1A4, 389, 393,
15 I=01,
16 XTAB = -2.717022143,
17 XTAB(2) = -2.158263+00, -2.084139+00, -2.010015+00, -1.935891+00, -1.861766+00,
18 -1.787642+00, -1.713517+00, -1.633333+00, -1.552268+00, -1.491144+00, -1.417019+00,
19 -1.342895+00, -1.268770+00, -1.194846+00, -1.120522+00, -1.046397+00, -9.722726-01,
20 -A.681482-01, -8.240237-01, -7.498993-01, -6.757748-01, -6.016504-01, -5.275259-01,
21 -4.534014-01, -3.792768-01, -3.051523-01, -2.310278-01, -1.569032-01, -3.376257-02,
22 XTAB(31) = 0.000000 , 7.301470-03, 1.480773-02, 2.248320-02, 3.035240-02,
23 1.839005-02, 4.655763-02, 5.487080-02, 6.331403-02, 7.188499-02, 8.057737-02,
24 A.939333-02, 9.832679-02, 1.073762-01, 1.165444-01, 1.259282-01, 1.352258-01,
25 1.447381-01, 1.543664-01, 1.641102-01, 1.739715-01, 1.839499-01, 1.940455-01,
26 2.042591-01, 2.145957-01, 2.250502-01, 2.356269-01, 2.464870-01, 2.571494-01,
27 2.676082-01, 2.780790-01, 2.885548-01, 2.989977-01, 3.094342-01, 3.197972-01,
28 3.301202-01, 3.404461-01, 3.507206-01, 3.609625-01, 3.711967-01, 3.813872-01,
29 3.915503-01, 4.016734-01, 4.117679-01, 4.218635-01, 4.321029-01, 4.421489-01,
30 4.521439-01, 4.620973-01, 4.720099-01, 4.819390-01, 4.918356-01, 5.016912-01,
31 5.115829-01, 5.214410-01, 5.318231-01, 5.421098-01, 5.523693-01, 5.626000-01,
32 5.728096-01, 5.830457-01, 5.932676-01, 6.034578-01, 6.136905-01, 6.239089-01,
33 A.340435-01, 6.443033-01, 6.545275-01, 6.647377-01, 6.749371-01, 6.851697-01,
34 6.953931-01, 7.055998-01, 7.158182-01, 7.260608-01, 7.363012-01, 7.465105-01,
35 7.567564-01, 7.670198-01, 7.772841-01, 7.875275-01, 7.978002-01, 8.080852-01,
36 A.183716-01, 8.286478-01, 8.389705-01, 8.492908-01, 8.595882-01, 8.699128-01,
37 A.802965-01, 8.906735-01, 9.010085-01, 9.113705-01, 9.218289-01, 9.322654-01,
38 9.426602-01, 9.531054-01, 9.635785-01, 9.740826-01, 9.845947-01, 9.950968-01,
39 1.005645+00, 1.016230+00, 1.026838+00, 1.037423+00, 1.048058+00, 1.058743+00,
40 1.069428+00, 1.080102+00, 1.090814+00, 1.101596+00, 1.112398+00, 1.123156+00,
41 1.133972+00, 1.144838+00, 1.155729+00, 1.166644+00, 1.177561+00, 1.188519+00,
42 1.199540+00, 1.210586+00, 1.221615+00, 1.232694+00, 1.243838+00, 1.255024+00,
43 1.266164+00, 1.277358+00, 1.288631+00, 1.299893+00, 1.311229+00, 1.322551+00,
44 1.333927+00, 1.345376+00, 1.356861+00, 1.368309+00, 1.379825+00, 1.391401+00,
45 1.403013+00, 1.414673+00, 1.426313+00, 1.438029+00, 1.449814+00, 1.461640+00,
46 1.473431+00, 1.485295+00, 1.497217+00, 1.509186+00, 1.521200+00, 1.533212+00,
47 1.545280+00, 1.557436+00, 1.569644+00, 1.581815+00, 1.594050+00, 1.606344+00,
48 1.618703+00, 1.631199+00, 1.643501+00, 1.655969+00, 1.668528+00, 1.681135+00,
49 1.693686+00, 1.706319+00, 1.719039+00, 1.731799+00, 1.744615+00, 1.757420+00,
50 1.770315+00, 1.783289+00, 1.796325+00, 1.809308+00, 1.822383+00, 1.835511+00,
51 1.848721+00, 1.861971+00, 1.875216+00, 1.888525+00, 1.901951+00, 1.915432+00,
52 1.928857+00, 1.942360+00, 1.955945+00, 1.969594+00, 1.983300+00, 1.996984+00,

53. 2.010762+00, 2.024642+00, 2.038590+00, 2.052464+00, 2.066424+00, 2.080470+00, 2.094577+00, 2.108742+00, 2.122895+00, 2.137126+00, 2.151483+00, 2.165896+00,
54. 2.180235+00, 2.194461+00, 2.209143+00, 2.223752+00, 2.238402+00, 2.253021+00, 2.267734+00, 2.282540+00, 2.297421+00, 2.312224+00, 2.327134+00, 2.342127+00,
55. 2.357161+00, 2.372277+00, 2.387358+00, 2.402533+00, 2.417826+00, 2.433179+00, 2.448450+00, 2.463840+00, 2.479372+00, 2.494980+00, 2.510441+00, 2.526017+00,
56. 2.541671+00, 2.557418+00, 2.573240+00, 2.589888+00, 2.604861+00, 2.620877+00, 2.636924+00, 2.653033+00, 2.669182+00, 2.685391+00, 2.701599+00, 2.717807+00,
57. 2.734016+00, 2.750225+00, 2.766434+00, 2.782643+00, 2.798852+00, 2.815061+00, 2.831270+00, 2.847479+00, 2.863688+00, 2.879897+00, 2.896106+00, 2.912315+00,
58. 2.928524+00, 2.944733+00, 2.960942+00, 2.977151+00, 2.993360+00, 3.009569+00, 3.025778+00, 3.041987+00, 3.058196+00, 3.074405+00, 3.090614+00, 3.106823+00,
59. 3.123032+00, 3.139241+00, 3.155450+00, 3.171659+00, 3.187868+00, 3.204077+00, 3.220286+00, 3.236495+00, 3.252704+00, 3.268913+00, 3.285122+00, 3.301331+00,
60. 3.317540+00, 3.333749+00, 3.349958+00, 3.366167+00, 3.382376+00, 3.398585+00, 3.414794+00, 3.431003+00, 3.447212+00, 3.463421+00, 3.479630+00, 3.495839+00,
61. 3.512048+00, 3.528257+00, 3.544466+00, 3.560675+00, 3.576884+00, 3.593093+00, 3.609302+00, 3.625511+00, 3.641720+00, 3.657929+00, 3.674138+00, 3.690347+00,
62. 3.706556+00, 3.722765+00, 3.738974+00, 3.755183+00, 3.771392+00, 3.787601+00, 3.803810+00, 3.819019+00, 3.835228+00, 3.851437+00, 3.867646+00, 3.883855+00,
63. 3.900064+00, 3.916273+00, 3.932482+00, 3.948691+00, 3.964900+00, 3.981109+00, 3.997318+00, 4.013527+00, 4.029736+00, 4.045945+00, 4.062154+00, 4.078363+00,
64. 4.094572+00, 4.110781+00, 4.126990+00, 4.143199+00, 4.159408+00, 4.175617+00, 4.191826+00, 4.208035+00, 4.224244+00, 4.240453+00, 4.256662+00, 4.272871+00,
65. 4.289080+00, 4.305289+00, 4.321498+00, 4.337707+00, 4.353916+00, 4.370125+00, 4.386334+00, 4.402543+00, 4.418752+00, 4.434961+00, 4.451170+00, 4.467379+00,
66. 4.483588+00, 4.500000+00, 4.516209+00, 4.532418+00, 4.548627+00, 4.564836+00, 4.581045+00, 4.597254+00, 4.613463+00, 4.629672+00, 4.645881+00, 4.662090+00,
67. 4.678300+00, 4.694509+00, 4.710718+00, 4.726927+00, 4.743136+00, 4.759345+00, 4.775554+00, 4.791763+00, 4.807972+00, 4.824181+00, 4.840390+00, 4.856600+00,
68. 4.872809+00, 4.889018+00, 4.905227+00, 4.921436+00, 4.937645+00, 4.953854+00, 4.970063+00, 4.986272+00, 5.002481+00, 5.018690+00, 5.034900+00, 5.051109+00,
69. 5.067318+00, 5.083527+00, 5.100000+00, 5.116209+00, 5.132418+00, 5.148627+00, 5.164836+00, 5.181045+00, 5.197254+00, 5.213463+00, 5.229672+00, 5.245881+00,
70. 5.262090+00, 5.278300+00, 5.294509+00, 5.310718+00, 5.326927+00, 5.343136+00, 5.359345+00, 5.375554+00, 5.391763+00, 5.407972+00, 5.424181+00, 5.440390+00,
71. 5.456600+00, 5.472809+00, 5.489018+00, 5.505227+00, 5.521436+00, 5.537645+00, 5.553854+00, 5.570063+00, 5.586272+00, 5.602481+00, 5.618690+00, 5.634900+00,
72. 5.651109+00, 5.667318+00, 5.683527+00, 5.700000+00, 5.716209+00, 5.732418+00, 5.748627+00, 5.764836+00, 5.781045+00, 5.797254+00, 5.813463+00, 5.829672+00,
73. 5.845881+00, 5.862090+00, 5.878300+00, 5.894509+00, 5.910718+00, 5.926927+00, 5.943136+00, 5.959345+00, 5.975554+00, 5.991763+00, 6.007972+00, 6.024181+00,
74. 6.040390+00, 6.056600+00, 6.072809+00, 6.089018+00, 6.105227+00, 6.121436+00, 6.137645+00, 6.153854+00, 6.170063+00, 6.186272+00, 6.202481+00, 6.218690+00,
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119.	2.369016+00,	2.378054+00,	2.387084+00,	2.396164+00,	2.405306+00,	2.414452+00,
120.	2.423551+00,	2.432706+00,	2.441922+00,	2.451121+00,	2.460367+00,	2.469592+00,
121.	2.479875+00,	2.489199+00,	2.497538+00,	2.506828+00,	2.516185+00,	2.525594+00,
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124.	2.649415+00,	2.659091+00,	2.668794+00,	2.678451+00,	2.688185+00,	2.697993+00,
125.	2.707775+00,	2.732426+00,	2.752837+00,	2.773632+00,	2.794457+00,	2.815713+00,
126.	2.837125+00,	2.858968+00,	2.880963+00,	2.903398+00,	2.925982+00,	2.949010+00,
127.	2.972203+00,	2.995824+00,	3.019610+00,	3.043849+00,	3.068200+00,	3.093038+00,
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133.	4.039775+00,	4.079409+00,	4.119896+00,	4.161202+00,	4.203101+00,	4.245708+00,
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163.	7523623-01,	7670193-01,	7627715-01,	7617132-01,	7572884-01,	
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170.	.6426817-01.	.6402613-01.	.6358041-01.	.6313236-01.	.6302701-01.
171.	.6257047-01.	.6212778-01.	.6168271-01.	.6158144-01.	.6112893-01.
172.	.6069972-01.	.6024822-01.	.5980652-01.	.5970934-01.	.5926585-01.
173.	.5882945-01.	.5839251-01.	.5829873-01.	.5785751-01.	.5742499-01.
174.	.5699172-01.	.5690018-01.	.5646392-01.	.5603596-01.	.5560859-01.
175.	.5552114-01.	.5508721-01.	.5466501-01.	.5424221-01.	.5381886-01.
176.	.5373515-01.	.5331152-01.	.5289380-01.	.5247711-01.	.5239642-01.
177.	.5197575-01.	.5156357-01.	.5115177-01.	.5107499-01.	.5065787-01.
178.	.5025187-01.	.4984652-01.	.4944002-01.	.4936841-01.	.4896109-01.
179.	.4856149-01.	.4815264-01.	.4809217-01.	.4768925-01.	.4729632-01.
180.	.4690346-01.	.4651106-01.	.4644444-01.	.4605125-01.	.4566580-01.
181.	.4528021-01.	.4521666-01.	.4482826-01.	.4444893-01.	.4407019-01.
182.	.4369232-01.	.4363269-01.	.4325465-01.	.4288283-01.	.4251253-01.
183.	.4245630-01.	.4208263-01.	.4171773-01.	.4135410-01.	.4099175-01.
184.	.4093958-01.	.4057667-01.	.4022049-01.	.3986513-01.	.3981643-01.
185.	.3945852-01.	.3910982-01.	.3876192-01.	.3841440-01.	.3837039-01.
186.	.3802357-01.	.3768299-01.	.3734301-01.	.3730209-01.	.3696023-01.
187.	.3662703-01.	.3624443-01.	.3596376-01.	.3592116-01.	.3559070-01.
188.	.3526602-01.	.3494323-01.	.3490944-01.	.3458410-01.	.3426711-01.
189.	.3395146-01.	.3363690-01.	.3360707-01.	.3329298-01.	.3298506-01.
190.	.3267805-01.	.3264969-01.	.3234089-01.	.3204050-01.	.3174130-01.
191.	.3144330-01.	.3141753-01.	.3112035-01.	.3082880-01.	.3053867-01.
192.	.3051560-01.	.3022381-01.	.2993991-01.	.2965724-01.	.2937561-01.
193.	.2935732-01.	.2907653-01.	.2880142-01.	.2852754-01.	.2851270-01.
194.	.2823777-01.	.2797035-01.	.2770382-01.	.2743860-01.	.2742794-01.
195.	.2716386-01.	.2690519-01.	.2664775-01.	.2633985-01.	.2638162-01.
196.	.2613021-01.	.2587954-01.	.2587486-01.	.2562205-01.	.2537792-01.
197.	.2513454-01.	.2489261-01.	.2489198-01.	.2464992-01.	.2441407-01.
198.	.2417887-01.	.2418065-01.	.2394456-01.	.2328415-01.	.2305130-01.
199.	.2258082-01.	.2234982-01.	.2184737-01.	.2165726-01.	.2120171-01.
200.	.2097349-01.	.2052470-01.	.2029940-01.	.1985730-01.	.1963418-01.
201.	.1920001-01.	.1897978-01.	.1855351-01.	.1833705-01.	.1791965-01.
202.	.1770584-01.	.1749251-01.	.1708367-01.	.1687640-01.	.1647755-01.
203.	.1627447-01.	.1587925-01.	.1568209-01.	.1548768-01.	.1510978-01.
204.	.1491654-01.	.1454952-01.	.1436077-01.	.1417266-01.	.1381578-01.
205.	.1363238-01.	.1328594-01.	.1310527-01.	.1292623-01.	.1258766-01.
206.	.1240935-01.	.1223101-01.	.1189912-01.	.1172001-01.	.1153997-01.
207.	.1135603-01.	.1102771-01.	.1084484-01.	.1065797-01.	.1046962-01.
208.	.1014572-01.	.9959042-02.	.9771958-02.	.9584032-02.	.9398765-02.
209.	.9214609-02.	.8904354-02.	.8731542-02.	.8557348-02.	.8385510-02.
210.	.8216840-02.	.8051031-02.	.7888713-02.	.7730223-02.	.7574705-02.
211.	.7421792-02.	.7272206-02.	.7124778-02.	.6980280-02.	.6837820-02.
212.	.6979777-02.	.6559575-02.	.6423758-02.	.6288760-02.	.6155485-02.
213.	.6025447-02.	.5897075-02.	.5769400-02.	.5642637-02.	.5517396-02.
214.	.5393355-02.	.5271451-02.	.5231294-02.	.5111111-02.	.4992592-02.
215.	.4875421-02.	.4760606-02.	.4720202-02.	.4606734-02.	.4495286-02.
216.	.4385522-02.	.4345455-02.	.4237374-02.	.4131313-02.	.4090909-02.
217.	.3986532-02.	.3983838-02.	.3843434-02.	.3742761-02.	.3702020-02.
218.	.3603030-02.	.3506397-02.	.3466667-02.	.3372727-02.	.3333333-02.
219.	.3242088-02.	.3203030-02.	.3164646-02.	.3075758-02.	.3037374-02.
220.	.2951178-02.	.2912458-02.	.2874411-02.	.2790909-02.	.2752189-02.



221.	.2713805-02, .2674747-02, .2595623-02, .2557912-02, .2520202-02,	09100	N
222.	.2482492-02, .2445115-02, .2407744-02, .2334007-02, .2297643-02,	09201	N
223.	.2260943-02, .2224242-02, .2187542-02, .2151179-02, .2115151-02,	09202	N
224.	.2079125-02, .2043771-02, .2008754-02, .1973737-02, .1967340-02,	09301	N
225.	.1932660-02, .1897306-02, .1872727-02,	09302	N
226.	SEND	09401	N
227.	10.46 0.0 2.30 1 .297 .381 .46 .614	09402	N
228.	0.0 .0692 .161 .08 1.0	09501	N
229.	.766 .881 .95	11100	N
230.	1.24+07 -1.178+07 -1.139+07 -1.088+07 -9.930+06 -9.232+06 -8.511+06	11201	N
231.	-7.004+06 -5.200+06 -3.418+06 -2.034+06 -1.251+06 -6.272+06	11202	N
232.	-1.174+06 1.429-01 1.429-01 1.429-01 1.429-01 1.429-01 1.429-01	12100	N
233.	1.429-01 1.429-01 1.429-01 1.429-01 1.429-01 1.429-01	12201	N
234.	3 3	12202	N
235.	2	12203	N
236.	H HYDROGEN 1.008 -1.0	12204	N
237.	O OXYGEN 16.0 -6.0	13100	N
238.	12		
239.	H .19396 H -.32 H2 .28302		
240.	H2 -.38 H2O .7704		
241.	OH .7421 OH -.81		
242.	O -.7 O2 .9553		
243.	300. 1000. 5000.		
244.	H 0.25 E+01 0. J 9/65H 1. G 300. 5000.		
245.	0.25471620E+05-0.46011763E+00 0.25 E+01 0. 0.		
246.	0. 0. 0.25471627E+05-0.46011762E+00		
247.	0. 0. J 6/620 1. G 300. 5000.		
248.	0.25420594E+01-0.27550619E-04-0.31028033E-08 0.45510674E-11-0.43680515E-15		
249.	0.25230803E+05 0.49203080E+01 0.29464287E+01-0.16381665E-02+0.24210316E-05		
250.	-0.16028432E-08 0.38906964E-12 0.29147644E+05 0.29639949E+01		
251.	02 J 9.650 2. G 300. 5000.		
252.	0.16219535E+01 0.73618264E-03-0.19652228E-06 0.36201558E-10-0.28945627E-14		
253.	-0.12019825E+04 0.36150900E+01 0.36255985E+01-0.18782184E-02 0.70554544E-05		
254.	-0.67635137E-08 0.21555993E-11-0.10475226E+04 0.43052778E+01		
255.	H2 0.31001901E+01 0.51119464E-03 0.52644210E-07-0.34904973E-10 0.36945345E-14		
256.	0.17738042E+03-0.19629421E+01 0.30574451E+01 0.26765200E-02-0.58099162E-05		
257.	0.55210391E-08-0.18122739E-11-0.98890474E+03-0.22997056E+01		
258.	OH J 3/660 1. H 1. G 300. 5000.		
259.	0.29106427E+01 0.95931650E-03-0.19441702E-06 0.13756646E-10 0.14224542E-15		
260.	0.39353815E+04 0.54423445E+01 0.38375943E+01-0.10778858E-02 0.96810378E-06		
261.	0.18713972E-09-0.22571094E-12 0.36412823E+04 0.49370009E+00		
262.	H2 J 3/61H 2. U 1. G 300. 5000.		
263.	0.27167633E+01 0.29451374E-02-0.80224374E-06 0.10226682E-09-0.48472145E-14		
264.	-0.20905826E+05 0.66305671E+01 0.40701275E+01-0.11084499E-02 0.41521180E-05		
265.	-0.29637404E-08 0.80702103E-12-0.30279722E+05-0.32270046E+00		
266.	13 LAST		
267.	STATUS		
268.	TWE 833. .838. .825. .817. .816. .816. .819.		
269.	828. .829. .805. .700. .650. .575. .490.		
270.	447. .466. .455. .440. .422. .805. .		
271.	755. .717. .605. .575. .492. .437. .		
272.	400. .395. .394. .		
273.	SEND		
274.			
275.			
276.			

LAST 5

8.1.2 Sample Case 1, Output

JANNAF BOUNDARY LAYER INTEGRAL MATRIX PROCEDURE

BLIMP-J MOD 2 JULY 1975

ACUREX CORP. AEROTHERM DIV., MT. VIEW, CALIF. 29 JUN 75 09:25:26

CASE SSME-NPL (FIRST GUESS) SAMPLE CASE 1 01100 N

CONTROL NUMBERS 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20

3 1 2 0 0 6 2 3 2 1 0 2 0 1 0 0 0 0 0 0

ETA VALUES

U/UE TO NODAL PT.
NORM. ETA AT WHICH
ETA NORM.

9.500-01 10 0.000 2.808-03 6.808-03 1.557-02 2.703-02 4.835-02 1.465-01 4.154-01 7.219-01
1.000+00 1.203+00 2.500+00

CASE 1.00000+00

TOTAL ENTHALPY, J/KG -6.95010+05

TOTAL PRESSURE, N/M2 2.04770+07

INCID. RAD FLUX, W/M2 0.00000

KENDALL TURR. MODEL

MIXING LENGTH CONSTANT = 4.4000-01

SUBLAYER CONSTANT, YAP = 1.1823+01

CLAUSER NUMMER = 1.8000-02

TURBULENT PRANDTL NUMMER = 9.0000-01

TURBULENT SCHMIDT NUMMER = 9.0000-01

TRANSITION MOM. THICK. RE = 0.0000

CASE 1 - - - - - 29 JUN 75 09:25:26

RELATIVE ELEMENTAL COMPOSITIONS, ATOMIC WTS/UNIT MASS

SYMBOL	ELEMENT	ATOMIC WT	EDGE GAS	PYRO. GAS 1	CHAR 1	PYRO. GAS 2	CHAR 2	PYRO. GAS 3	CHAR 3
H	HYDROGEN	1.00800	.1417234	.0000000	.0000000	.0000000	.0000000	.0000000	.0000000
O	OXYGEN	16.00000	.0535714	.0000000	.0000000	.0000000	.0000000	.0000000	.0000000

THERMODYNAMIC PROPERTY CURVE-FIT DATA (SEE MANUAL FOR FORMAT)

	J 9/65H	1.	0.	0.	0.6	300.000	5000.000	1		
H	1000.00	.25000000+01	.00000000	.00000000	.00000000	.00000000	.00000000	.00000000	.00000000	.25471627+05
	5000.00	.25000000+01	.00000000	.00000000	.00000000	.00000000	.00000000	.00000000	.00000000	.25471620+05
	5000.00	.00000000	.00000000	.00000000	.00000000	.00000000	.00000000	.00000000	.00000000	.00000000
										.46011762+00
										.46011763+00
										.00000000

0	1000.00	5000.00	5000.00	U2	1000.00	5000.00	5000.00	H2	1000.00	5000.00	5000.00	OH	1000.00	5000.00	5000.00	H2O	1000.00	5000.00	5000.00
0	1000.00	5000.00	5000.00	U2	1000.00	5000.00	5000.00	H2	1000.00	5000.00	5000.00	OH	1000.00	5000.00	5000.00	H2O	1000.00	5000.00	5000.00
1	2944287+01	25420596+01	00000000	1	36235985+01	36219535+01	00000000	2	30574451+01	31001901+01	00000000	1	38375943+01	29106427+01	00000000	2	40701275+01	27167633+01	00000000
0.6	15381665+02	27550619+04	00000000	0.6	16782184+02	73619264+03	00000000	0.6	26765200+02	51119464+03	00000000	0.6	10778858+02	95931650+03	00000000	0.6	11084499+02	29451374+02	00000000
300.000	24210316+05	31028033+08	00000000	300.000	70554544+05	19652228+06	00000000	300.000	55099162+05	52644210+07	00000000	300.000	96830378+06	19441702+06	00000000	300.000	41521180+05	80224374+06	00000000
5000.000	16028432+08	45510674+11	00000000	5000.000	67635137+08	36201558+10	00000000	5000.000	18713972+09	13756646+10	00000000	5000.000	18713972+09	13756646+10	00000000	5000.000	29637404+08	10226682+09	00000000
29147644+05	29230803+05	00000000	21555993+11	10475226+04	28945627+14	00000000	18122739+11	98890474+03	87738042+03	00000000	22571094+12	36412823+04	39353815+04	00000000	80702103+12	30279722+05	29905826+05	00000000	
29639949+01	49203080+01	00000000	43052778+01	36150960+01	00000000	00000000	22997056+01	19629421+01	00000000	00000000	49370009+00	54623445+01	00000000	32270046+00	66305671+01	00000000	00000000		

ELEMENT HYDROGEN OXYGEN
BASE SP D

MOLECULAR TRANSPORT PROPERTIES
VISCOSITY BUDRENBURG - WILKE MIXTURE FORMULA WITH MU(I) CALCULATED ON
THE BASIS OF D(I,I) = DBAR/G(I)**2

THERMAL CONDUCTIVITY MASON - SAXENA MIXTURE FORMULA WITH EUCKEN CORRECTION

DIFFUSION COEFFICIENTS D(I,J) = DBAR/(F(I)*F(J)) WITH DBAR BASED ON
SIGMA = 3.4670, EPOVRK = 106.7000, AND HREF = 32.0000

METHODS EMPLOYED

0 CONDENSED PHASE, VALUES FOR F(I) AND G(I) SET EQUAL TO 1.E+10

1 VALUES FOR F(I) (OR G(I)) INPUT DIRECTLY

2 VALUES FOR F(I) (OR G(I)) CALCULATED BY F(I) = (M(I)/FITMOL)**FFA AND
G(I) = (M(I)/FITMOL)**GGA WHERE M(I) IS SPECIES MOLECULAR WEIGHT,
FITMOL = 26.7000, AND FFA = .4890, FITGMA = 24.3000, AND GGA = .4540

SPECIES	F(I) METHOD	G(I) METHOD	SPECIES	F(I) METHOD	G(I) METHOD
H	.194	.320	O	.706	.700
O2	.955	1.000	H2	.283	.380
OH	.742	.810	H2O	.770	.920

STAGNATION SOLUTION FOLLOWED BY BOUNDARY-LAYER EDGE EXPANSION

CP-FROZEN CP-EQUIL GAMMA
 J/KG-K J/KG-K
 .37372+04 .77034+04 .11474+01
 TEMP = 3652.8923 DEG-K PRES = 2.048+07 N/M2 MCL WT = 135.4858375
 ENTHALPY = -.6950098+06 J/KG ENTROPY = .17235+05 J/KG-K
 DENSITY = .913343+01 KG/M3
 VEL = 0.000 M/S MACH NO. = 0.000
 SPECIES MOLE FR. SPECIES MOLE FR.
 H .28696-01 O .26787-02
 H2 .24838+00 OH .40017-01 H2O .67734+00

STATION NO. 1

CP-FROZEN CP-EQUIL GAMMA
 J/KG-K J/KG-K
 .37359+04 .76779+04 .11474+01
 TEMP = 3643.4798 DEG-K PRES = 2.000+07 N/M2 MCL WT = 135.5466831
 ENTHALPY = -.7477823+06 J/KG ENTROPY = .17235+05 J/KG-K
 DENSITY = .894764+01 KG/M3
 VEL = 3.249+02 M/S MACH NO. = 2.029-01
 SPECIES MOLE FR. SPECIES MOLE FR.
 H .28463-01 O .26308-02
 H2 .24824+00 OH .39574-01 H2O .67825+00

OUTPUT DELETED

STATION NO. 31

CP-FROZEN CP-EQUIL GAMMA
 J/KG-K J/KG-K
 .30256+04 .30268+04 .12417+01
 TEMP = 1418.3794 DEG-K PRES = 3.835+04 N/M2 MCL WT = 141.1196256
 ENTHALPY = -.9996650+07 J/KG ENTROPY = .17235+05 J/KG-K
 DENSITY = .458824-01 KG/M3
 VEL = 4.314+03 M/S MACH NO. = 4.234+00
 SPECIES MOLE FR. SPECIES MOLE FR.
 H .49895-05 O .60582-11
 H2 .24400+00 OH .32684-06 H2O .89666-11
 .75600+00

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AXIAL DISTANCE, METERS	.28247+00	.26307+00	.20486+00	.15635+00	.12725+00	.10785+00	.69042-01	.49639-01
	.30237-01	.20535-01	.44188-02	.00000	.71814-02	.17698-01	.25396-01	.28086-01
	.65661-01	.14276+00	.20224+00	.25421+00	.25778+00	.37788+00	.45935+00	.58642+00
	.78840+00	.10437+01	.15694+01	.21198+01	.26197+01	.28870+01	.30780+01	
FALL LENGTH, METERS	.25390-01	.44815-01	.10458+00	.15782+00	.19005+00	.21153+00	.25449+00	.27588+00
	.29628+00	.30617+00	.32236+00	.32678+00	.33398+00	.34485+00	.35335+00	.35650+00
	.40327+00	.49812+00	.57017+00	.63241+00	.63665+00	.77806+00	.87235+00	.10171+01
	.12423+01	.15202+01	.20757+01	.26424+01	.31497+01	.34191+01	.36111+01	
RADIUS, METERS	.22669+00	.22586+00	.21305+00	.19115+00	.17732+00	.16810+00	.14966+00	.14066+00
	.13442+00	.13250+00	.13095+00	.13088+00	.13138+00	.13403+00	.13761+00	.13925+00
	.16710+00	.22233+00	.26300+00	.29724+00	.29954+00	.37418+00	.42162+00	.49092+00
	.59050+00	.70007+00	.87911+00	.10135+01	.10989+01	.11326+01	.11521+01	
XL (KG/S) **2	.29818-03	.52647-03	.12340-02	.18754-02	.22692-02	.25338-02	.30703-02	.33359-02
	.35814-02	.36966-02	.38778-02	.39251-02	.39963-02	.40834-02	.41353-02	.41510-02
	.43528-02	.49867-02	.55523-02	.60825-02	.61198-02	.74061-02	.82984-02	.97024-02
	.11949-01	.14808-01	.20728-01	.26935-01	.32536-01	.35474-01	.37536-01	
PRESSURE RATIO	.97670+00	.97625+00	.96878+00	.94836+00	.92633+00	.90408+00	.81798+00	.73996+00
	.64945+00	.60086+00	.48369+00	.44647+00	.32484+00	.19596+00	.12534+00	.10473+00
	.76277-01	.55609-01	.42513-01	.33951-01	.33607-01	.21202-01	.16478-01	.11899-01
	.80510-02	.56426-02	.35064-02	.25956-02	.21512-02	.19737-02	.18727-02	
STATIC PRESSURE, N/M2	.20000+08	.19991+08	.19838+08	.19420+08	.18968+08	.18513+08	.16750+08	.15152+08
	.13299+08	.12304+08	.99045+07	.91424+07	.66518+07	.40127+07	.25665+07	.21445+07
	.15619+07	.11387+07	.87053+06	.69522+06	.68817+06	.43415+06	.33741+06	.24366+06
	.16486+06	.11554+06	.71800+05	.53151+05	.44050+05	.40416+05	.38348+05	
EDGE VELOCITY, M/S	.32494+03	.32808+03	.37677+03	.48678+03	.58438+03	.67029+03	.94313+03	.11510+04
	.13722+04	.14870+04	.17634+04	.18534+04	.21666+04	.25671+04	.28569+04	.29608+04
	.31299+04	.32828+04	.34019+04	.34991+04	.34991+04	.36724+04	.37586+04	.38620+04
	.39753+04	.40692+04	.41829+04	.42482+04	.42867+04	.43038+04	.43140+04	
BETAV	.18378+00	.79387-01	.80382+00	.16518+01	.22525+01	.27910+01	.46186+01	.48389+01
	.50312+01	.61694+01	.76184+01	.13836+02	.15951+02	.16072+02	.18147+02	.19328+02
	.57342+00	.51615+00	.44504+00	.70084+00	.36069+00	.44050+00	.39847+00	.35860+00
	.23474+00	.20735+00	.13356+00	.13162+00	.90760-01	.55879-01	.24358+00	
BETAP	.18378+00	.79387-01	.80382+00	.16518+01	.22525+01	.27910+01	.46186+01	.48389+01
	.50312+01	.61694+01	.76184+01	.13836+02	.15951+02	.16072+02	.18147+02	.19328+02
	.57342+00	.51615+00	.44504+00	.70084+00	.36069+00	.44050+00	.39847+00	.35860+00
	.23474+00	.20735+00	.13356+00	.13162+00	.90760-01	.55879-01	.24358+00	
INCID RAD.FLUX, W/M2	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000
	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000
	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000
	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000

63800003	82500003	81700003	81600003	81600003	81900003	82800003
80500003	70000003	65000003	57500003	49000003	46700003	46600003
55500003	40000003	42200003	80500003	75500003	71700003	66500003
49200003	43700003	41000003	40000003	39500003	39400003	

[illegible]

000000.	000000.	000000.	000000.	000000.	000000.
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[illegible]

STATION 1 - - - - - AXIAL POSITION - .28247+00 METERS - - - - - 29 JUN 75 09125126

ITERATED VALUES		DAMP	MAX. LIN			MAX. ERRORS IN CONSERVATION EQS.					
TIME	ALPH		FPPW	ERROR	MOMENTUM	ENERGY	H				
1	10.68811	.812	2.1755	2.00	9	6.6+01	8	-5.5+04	11	1.6-02	0
2	12.13412	.994	2.3854	2.00	11	7.1+01	8	-6.0+04	11	5.0-03	0
3	13.54514	.293	2.3657	1.00	11	7.6+01	8	-6.3+04	11	2.4-03	0
4	14.97115	.722	2.3325	1.00	11	7.6+01	8	-6.3+04	11	1.3-03	0
5	16.41817	.295	2.2954	8.00	11	7.0+01	8	-5.8+04	11	5.3-04	0
6	17.87818	.621	2.1666	5.00	9	4.8+01	8	-4.2+04	8	3.0-04	0
7	19.29618	.433	2.19921	6.00	9	1.2+01	7	7.8+03	11	-1.3-03	0
8	20.56118	.388	2.19391	4.00	5	3.4+01	7	-2.2+02	10	1.9-04	0
9	21.77118	.382	2.19271	8.00	5	7.5+02	2	1.3+01	8	6.5-06	0
10	22.98118	.381	2.19251	8.00	5	1.2-02	3	2.1+00	3	7.9-06	0

ALPHA ⁺	RADIUS METERS	PRESSURE N/M ²	EDGE VEL. M/S	BETAP	BETAV	HEAT FLUXES--W/M ²	DIFFUSIONAL TOT ENTH	PERAD	QCOND
1.838+01	2.267+01	2.000+07	3.249+02	1.838-01	1.838-01	9.853+07	9.853+07	0.000	9.954+07

WALL SHEAR	MASS FLUXES KG/SM2		ELEMENTAL MASS DIFFUSIVE FLUXES KG/SM2 FOR	
	MFCHEMICAL	PYROL	TOTAL GAS	HYDROGEN OXYGEN
1	0.0000	0.0000	0.0000	0.0000
2	0.0000	0.0000	0.0000	0.0000
3	0.0000	0.0000	0.0000	0.0000
4	0.0000	0.0000	0.0000	0.0000
5	0.0000	0.0000	0.0000	0.0000
6	0.0000	0.0000	0.0000	0.0000
7	0.0000	0.0000	0.0000	0.0000
8	0.0000	0.0000	0.0000	0.0000
9	0.0000	0.0000	0.0000	0.0000
10	0.0000	0.0000	0.0000	0.0000
11	0.0000	0.0000	0.0000	0.0000
12	0.0000	0.0000	0.0000	0.0000
13	0.0000	0.0000	0.0000	0.0000
14	0.0000	0.0000	0.0000	0.0000
15	0.0000	0.0000	0.0000	0.0000
16	0.0000	0.0000	0.0000	0.0000
17	0.0000	0.0000	0.0000	0.0000
18	0.0000	0.0000	0.0000	0.0000
19	0.0000	0.0000	0.0000	0.0000
20	0.0000	0.0000	0.0000	0.0000
21	0.0000	0.0000	0.0000	0.0000
22	0.0000	0.0000	0.0000	0.0000
23	0.0000	0.0000	0.0000	0.0000
24	0.0000	0.0000	0.0000	0.0000
25	0.0000	0.0000	0.0000	0.0000
26	0.0000	0.0000	0.0000	0.0000
27	0.0000	0.0000	0.0000	0.0000
28	0.0000	0.0000	0.0000	0.0000
29	0.0000	0.0000	0.0000	0.0000
30	0.0000	0.0000	0.0000	0.0000
31	0.0000	0.0000	0.0000	0.0000
32	0.0000	0.0000	0.0000	0.0000
33	0.0000	0.0000	0.0000	0.0000
34	0.0000	0.0000	0.0000	0.0000
35	0.0000	0.0000	0.0000	0.0000
36	0.0000	0.0000	0.0000	0.0000
37	0.0000	0.0000	0.0000	0.0000
38	0.0000	0.0000	0.0000	0.0000
39	0.0000	0.0000	0.0000	0.0000
40	0.0000	0.0000	0.0000	0.0000
41	0.0000	0.0000	0.0000	0.0000
42	0.0000	0.0000	0.0000	0.0000
43	0.0000	0.0000	0.0000	0.0000
44	0.0000	0.0000	0.0000	0.0000
45	0.0000	0.0000	0.0000	0.0000
46	0.0000	0.0000	0.0000	0.0000
47	0.0000	0.0000	0.0000	0.0000
48	0.0000	0.0000	0.0000	0.0000
49	0.0000	0.0000	0.0000	0.0000
50	0.0000	0.0000	0.0000	0.0000
51	0.0000	0.0000	0.0000	0.0000
52	0.0000	0.0000	0.0000	0.0000
53	0.0000	0.0000	0.0000	0.0000
54	0.0000	0.0000	0.0000	0.0000
55	0.0000	0.0000	0.0000	0.0000
56	0.0000	0.0000	0.0000	0.0000
57	0.0000	0.0000	0.0000	0.0000
58	0.0000	0.0000	0.0000	0.0000
59	0.0000	0.0000	0.0000	0.0000
60	0.0000	0.0000	0.0000	0.0000
61	0.0000	0.0000	0.0000	0.0000
62	0.0000	0.0000	0.0000	0.0000
63	0.0000	0.0000	0.0000	0.0000
64				

NAME	RECORD	DATE	TIME
2.505+03	0.000	0.000	1.618-05
2.505+03	0.000	0.000	1.618-05

MOM TRANS HEAT TRANS		BLOWING PARAMETERS		ELEMENTAL MASS TRANSFER COEFFICIENTS,	
COEFF,	COEFF,	(NORM. BY $\rho H_0 \times U \times \Delta T$) FOR	CM, FOR	HYDROGEN	OXYGEN
CF/2	ST NO.	PYROL GAS	CHAR	TOTAL GAS	
2.651-03	3.094-01	0.000	0.000	0.000	
				-1.548-04	-1.548-04

[†]The quantities are used for RESTART input.

MOMENTUM DISPLACE: EFFECTIVE ENTHALPY REYNOLDS MASS THICKNESS FOR
 THICKNESS, THICKNESS, BODY THICKNESS, NUMBER
 THETA DELSTAR DISPLACE. LAMBDA PER METER OXYGEN
 METERS METERS METERS METERS METERS
 1.100-04 2.284-05 2.284-05 1.572-04 3.699+07 -5.952-04 6.080-03

TOTAL HEAT THRUST TOTAL ACCELERATION INVISCID TOTAL
 TO WALL LOSS (N) WALL AREA PARAMETER-K MASS IN BL
 WATTS (M2) KG/S
 0.000 -5.029+02 0.000 9.784+08 6.387+00 6.387+00

NODAL INFORMATION		F		U/UE [†]		FPP		SHEAR		G, TOTAL		GP		GPP		STATIC		TEMP	
ETAT	DISTANCE FROM WALL METERS									ENTHALPY J/KG		J/KG		J/KG		ENTHALPY J/KG		DEG-K	
0.000	0.000	0.000	0.000	0.000	2.192+00	2.505+03	-1.165+07	1.313+07	8.962+06	1.313+07	8.962+06	1.313+07	8.962+06	1.313+07	8.962+06	1.313+07	8.962+06	8.330+02	
2.808-03	4.849-07	2.895-03	1.117-01	2.136+00	2.503+03	-1.096+07	1.359+07	5.676+07	-5.676+07	1.359+07	5.676+07	1.359+07	5.676+07	1.359+07	5.676+07	1.359+07	5.676+07	1.088+03	
6.808-03	1.379-04	1.598-02	2.322-01	1.141+00	2.499+03	-1.011+07	9.417+06	3.176+07	-1.011+07	9.417+06	3.176+07	9.417+06	3.176+07	9.417+06	3.176+07	9.417+06	3.176+07	1.378+03	
1.557-02	3.865-04	6.507-02	3.581-01	4.226+01	2.490+03	-9.007+06	4.301+06	9.235+06	-9.014+06	4.301+06	9.235+06	4.301+06	9.235+06	4.301+06	9.235+06	4.301+06	9.235+06	1.733+03	
2.703-02	7.675-04	1.484-01	4.254-01	2.167-01	2.477+03	-8.306+06	2.356+06	-2.757+06	-8.316+06	2.356+06	-2.757+06	2.356+06	-2.757+06	2.356+06	-2.757+06	2.356+06	-2.757+06	1.947+03	
4.835-02	1.558-05	3.290-01	4.900-01	1.129-01	2.450+03	-6.595+06	1.275+06	-4.681+05	-7.607+06	1.275+06	-4.681+05	1.275+06	-4.681+05	1.275+06	-4.681+05	1.275+06	-4.681+05	2.158+03	
1.465-01	5.814-05	1.355+00	6.243-01	3.605-02	2.311+03	-6.056+06	4.308+05	-2.854+05	-4.306+06	4.308+05	-2.854+05	4.308+05	-2.854+05	4.308+05	-2.854+05	4.308+05	-2.854+05	2.590+03	
4.154-01	1.953-04	4.824+00	7.680-01	2.208-02	1.865+03	-4.275+06	2.898+05	-5.391+03	-4.306+06	2.898+05	-5.391+03	2.898+05	-5.391+03	2.898+05	-5.391+03	2.898+05	-5.391+03	3.029+03	
7.219-01	3.730-04	9.478+00	8.799-01	1.764-02	1.204+03	-2.728+06	2.594+05	-1.844+04	-2.769+06	2.594+05	-1.844+04	2.594+05	-1.844+04	2.594+05	-1.844+04	2.594+05	-1.844+04	3.336+03	
1.000+00	5.485-04	1.417+01	9.500-01	9.798-03	5.909+02	-1.643+06	1.651+05	-1.667+04	-1.690+06	1.651+05	-1.667+04	1.651+05	-1.667+04	1.651+05	-1.667+04	1.651+05	-1.667+04	3.512+03	
1.203+00	6.821-04	1.777+01	9.783-01	5.375-03	2.666+02	-1.143+06	1.029+05	-1.255+04	-1.193+06	1.029+05	-1.255+04	1.029+05	-1.255+04	1.029+05	-1.255+04	1.029+05	-1.255+04	3.583+03	
2.500+00	1.565-03	4.161+01	1.000+00	0.000	0.000	-6.950+05	0.000	3.910+03	-7.478+05	0.000	3.910+03	0.000	3.910+03	0.000	3.910+03	0.000	3.910+03	3.643+03	

DISTANCE FROM WALL METERS		DENSITY RHO KG/M3		VISCOSITY MU N-S/M2		SPECIFIC HEAT J/KG-K		THERMAL COND. W/M-K		PRANDTL NUMBER		MODIFIED SCHMIDT NUMBER		MOLECULAR WEIGHT		MACH NUMBER		RHOSEPS /RHOE*MUE		TURBULENT PRANDTL NO	
0.000	4.072+01	2.862-05	2.610+03	1.594-01	4.684-01	5.453-01	1.410+01	0.000	0.000	0.000	0.000	0.000	0.000	1.410+01	1.410+01	4.027-02	1.870-01	0.000	0.000	9.000-01	
4.849-07	3.118+01	3.413-05	2.799+03	2.029-01	4.709-01	5.453-01	1.410+01	7.501-02	1.782+00	7.501-02	1.782+00	7.501-02	1.782+00	1.410+01	1.410+01	1.040-01	1.534+01	9.000-01	9.000-01	9.000-01	
1.379-06	2.461+01	3.989-05	3.002+03	2.536-01	4.721-01	5.453-01	1.410+01	1.170-01	1.534+01	1.170-01	1.534+01	1.170-01	1.534+01	1.410+01	1.410+01	1.283-01	3.029+01	9.000-01	9.000-01	9.000-01	
3.865-06	1.959+01	4.638-05	3.203+03	3.144-01	4.725-01	5.453-01	1.410+01	1.409+01	1.534+01	1.409+01	1.534+01	1.409+01	1.534+01	1.410+01	1.410+01	1.502-01	1.215+02	9.000-01	9.000-01	9.000-01	
7.675-06	1.742+01	5.008-05	3.304+03	3.502-01	4.724-01	5.453-01	1.410+01	1.387+01	1.534+01	1.387+01	1.534+01	1.387+01	1.534+01	1.410+01	1.410+01	1.878-01	9.797+01	9.000-01	9.000-01	9.000-01	
1.558-05	1.572+01	5.359-05	3.589+03	3.848-01	4.721-01	5.453-01	1.410+01	5.602-01	1.534+01	5.602-01	1.534+01	5.602-01	1.534+01	1.410+01	1.410+01	1.971-01	8.648+01	9.000-01	9.000-01	9.000-01	
5.814-05	1.309+01	6.049-05	3.529+03	4.531-01	4.711-01	5.457-01	1.409+01	5.634-01	1.534+01	5.634-01	1.534+01	5.634-01	1.534+01	1.409+01	1.409+01	2.006-01	7.096+01	9.000-01	9.000-01	9.000-01	
1.953-04	1.113+01	6.738-05	3.634+03	5.209-01	4.700-01	5.484-01	1.402+01	5.664-01	1.534+01	5.664-01	1.534+01	5.664-01	1.534+01	1.402+01	1.402+01	2.029-01	0.000	0.000	0.000	9.000-01	
3.730-04	9.995+00	7.257-05	3.690+03	5.703-01	4.696-01	5.542-01	1.387+01	5.634-01	1.534+01	5.634-01	1.534+01	5.634-01	1.534+01	1.387+01	1.387+01	1.878-01	9.797+01	9.000-01	9.000-01	9.000-01	
5.485-04	9.391+00	7.588-05	3.717+03	6.010-01	4.693-01	5.602-01	1.371+01	5.634-01	1.534+01	5.634-01	1.534+01	5.634-01	1.534+01	1.371+01	1.371+01	1.971-01	8.648+01	9.000-01	9.000-01	9.000-01	
6.821-04	9.148+00	7.733-05	3.728+03	6.144-01	4.692-01	5.634-01	1.371+01	5.634-01	1.534+01	5.634-01	1.534+01	5.634-01	1.534+01	1.371+01	1.371+01	2.006-01	7.096+01	9.000-01	9.000-01	9.000-01	
1.565-03	8.946+00	7.859-05	3.737+03	6.261-01	4.691-01	5.664-01	1.355+01	5.664-01	1.534+01	5.664-01	1.534+01	5.664-01	1.534+01	1.355+01	1.355+01	2.029-01	0.000	0.000	0.000	9.000-01	

0.000 4.849-07 1.379-06 3.865-06 7.675-06 1.558-05 5.814-05 1.953-04 3.730-04 5.485-04
 6.821-04 1.565-03

[†]The quantities are used for RESTART input.

[illegible]

H	3.791-13	6.904-10	1.260-07	6.977-06	3.931-05	1.546-04	1.287-03	6.019-03	1.399-02	2.128-02
	2.099-02	2.846-02								
O	1.241-27	2.753-20	3.356-15	2.736-11	1.311-09	2.795-08	3.145-06	9.616-05	6.035-04	1.458-03
	2.024-03	2.024-03								
O2	2.423-27	4.538-20	5.002-15	3.807-11	1.773-09	3.700-08	4.023-06	1.189-04	7.144-04	1.651-03
	2.238-03	2.833-03								
H2	2.445-01	2.445-01	2.445-01	2.445-01	2.445-01	2.444-01	2.440-01	2.433-01	2.440-01	2.458-01
	2.471-01	2.485-01								
OH	5.398-16	8.679-12	7.038-09	1.206-06	1.095-05	6.254-05	9.161-04	6.337-03	1.770-02	2.876-02
	3.436-02	3.952-02								
H2O	7.555-01	7.555-01	7.555-01	7.555-01	7.555-01	7.554-01	7.538-01	7.441-01	7.230-01	7.010-01
	6.493-01	6.781-01								

I	ETA(I) ⁺	U/UE ⁺	G(I,I) ⁺	SP(1,I,1) ⁺	SP(1,I,2)	SP(1,I,3)	SP(1,I,4)	SP(1,I,5)	SP(1,I,6)	SP(1,I,7)	SP(1,I,8)
1	0.000	0.000	-1.165+07	1.429+01							
2	1.248-03	5.052-02	-1.134+07	1.429-01							
3	3.022-03	1.194-01	-1.091+07	1.429-01							
4	7.686-03	2.517-01	-9.957+06	1.429-01							
5	1.462-02	3.481-01	-9.039+06	1.429-01							
6	3.371-02	4.504-01	-8.039+06	1.429-01							
7	1.184-01	5.975-01	-6.367+06	1.429-01							
8	3.732-01	7.503-01	-4.505+06	1.429-01							
9	6.331-01	8.504-01	-3.151+06	1.429-01							
10	1.000+00	9.500-01	-1.643+06	1.429-01							
11	1.229+00	9.812-01	-1.090+06	1.429-01							
12	2.500+00	1.000+00	-6.050+05	1.429-01							

8-14

OUTPUT DELETED

STATION 31 - - - - - AXIAL POSITION .30780+01 METERS - - - - -29 JUN 75 09:28:50

ITERATED VALUES

ITS	TIME	ALPH	FPPW	DAMP	MAY.LIM	MAX.ERRORS IN CONSERVATION EQS.
						ERROR MOMENTUM ENERGY H
1	1.81937.603	4.4667	.4999	1.-04 12	-1.9+01 10	-2.0+03 10 -3.3-03 0
2	3.13337.590	4.51431.0000	6.-05 12	-9.6+00 9	-1.1+03 10	-6.8-04 0
3	4.40937.590	4.52141.0000	6.-05 6	-7.2-01 3	-6.6+01 10	3.1-03 0
4	5.65937.590	4.52241.0000	1.-04 6	-9.4-02 10	4.6+01 3	6.6-05 0

ALPHA	RADIUS METERS	PRESSURE N/M2	EDGE VEL. M/S	BETAP	BETAV	HEAT FLUXES--W/M2
3.759+01	1.152+00	3.835+04	4.314+03	2.436+01	2.436+01	DIFFUSIONAL TOT ENTH REPAD GCOND
						2.996+06 0.000 2.995+06

WALL SHEAR MECHANICAL REMOVAL

WALL SHEAR N/M2	MASS FLUXES KG/SM2	CHAR	TOTAL GAS	ELEMENTAL MASS DIFFUSIVE FLUXES KG/SM2 FOR
1.021+03	0.000	0.000	0.000	1.110+06 -1.110+06
				HYDROGEN OXYGEN

MOM TRANS HEAT TRANS COEFF, CF/2

MOM TRANS	HEAT TRANS	BLOWING PARAMETERS	ELEMENTAL MASS TRANSFER COEFFICIENTS,
COEFF, CF/2	(NORM. BY RHO*U*ST) FOR	CM, FOR	
1.196-03	1.258-03	0.000	0.000
			HYDROGEN OXYGEN
			-1.962-03 -1.961-03

MOMENTUM DISPLAC: EFFECTIVE ENTHALPY REYNOLDS

MOMENTUM DISPLAC:	THICKNESS, BODY THICKNESS, NUMBER	MASS THICKNESS FOR
THICKNESS, THICKNESS, THETA DELSTAR	DISPLAC. LAMBDA PER METER	HYDROGEN OXYGEN
METERS METERS	METERS METERS	METERS METERS
6.430-03	7.262-03	9.280-03
		4.867+06 -2.851+00
		1.731+01

TOTAL HEAT TO WALL WATTS	THRUST LOSS (N)	TOTAL WALL AREA (M2)	ACCELERATION PARAMETER-K	INVISCID MASS IN BL KG/S	TOTAL MASS IN RL, KG/S
1.485+08	3.758+04	1.634+01	7.114-09	1.499+02	1.499+02

NODAL INFORMATION

ETA	DISTANCE FROM WALL METERS	F	U/UE	FPP	SHEAR N/M2	G, TOTAL ENTHALPY J/KG	GP	GPP	STATIC ENTHALPY J/KG	TEMP DEG-K
0.000	0.000	0.000	0.000	4.523+00	1.021+03	-1.273+07	2.640+07	4.619+08	-1.273+07	3.940+02
2.226-04	3.128-04	1.619-04	3.913-02	4.831+00	1.021+03	-1.249+07	3.026+07	2.029+08	-1.251+07	4.883+02
5.077-04	8.866-04	9.937-04	9.641-02	4.544+00	1.021+03	-1.211+07	3.274+07	-3.490+08	-1.219+07	6.174+02
1.506-03	3.188-05	6.874-03	2.149-01	2.032+00	1.020+03	-1.115+07	2.016+07	-1.619+08	-1.158+07	8.574+02
3.404-03	9.081-05	2.629-02	3.143-01	7.557-01	1.019+03	-1.013+07	8.611+06	-2.600+07	-1.105+07	1.056+03
9.246-03	3.082-04	1.094-01	4.236-01	2.394+01	1.014+03	-8.865+06	2.900+06	-1.970+06	-1.053+07	1.237+03
3.918-02	1.591-03	6.945-01	5.885-01	5.362-02	9.898+02	-6.848+06	6.835+05	-1.106+05	-1.007+07	1.394+03
1.636-01	7.221-03	3.886+00	7.423-01	1.214+02	9.061+02	-4.961+06	1.661+05	-5.491+05	-9.985+06	1.422+03
4.641-01	2.074-02	1.293+01	8.492-01	6.793+03	7.243+02	-3.335+06	1.041+05	-2.228+03	-1.004+07	1.403+03
1.000+00	4.453-02	3.117+01	9.500-01	3.216-03	3.498+02	-1.691+06	5.920+04	-1.699+03	-1.008+07	1.389+03
1.304+00	5.862-02	4.237+01	9.800-01	1.957-03	1.664+02	-1.119+06	3.950+04	-2.261+03	-1.005+07	1.401+03
2.500+00	1.119-01	8.705+01	1.000+00	0.000	0.000	-6.950+05	0.000	4.971+02	-9.994+06	1.419+03

DISTANCE FROM WALL METERS	DENSITY RHO KG/M3	VISCOSITY		THERMAL COND. W/M-K	PRANDTL NUMBER	MODIFIED SCHMIDT NUMBER	MOLECULAR WEIGHT	MACH NUMBER	RHOS*EPS /RHO*MU	TURBULENT PRANDTL NO
		MU N-S/M2	HEAT J/KG-K							
0.000	1.651-01	1.747-05	2.337+03	8.858-02	4.611-01	5.453-01	1.411+01	0.000	0.000	0.000
3.128-06	1.332-01	2.013-05	2.386+03	1.039-01	4.624-01	5.453-01	1.411+01	2.730-01	1.045-02	9.000-01
8.866-06	1.054-01	2.349-05	2.463+03	1.245-01	4.649-01	5.453-01	1.411+01	6.013-01	2.122-01	9.000-01
3.188-05	7.588-02	2.917-05	2.627+03	1.634-01	4.688-01	5.453-01	1.411+01	1.149+00	2.254+00	9.000-01
9.081-05	6.160-02	3.347-05	2.775+03	1.972-01	4.708-01	5.453-01	1.411+01	1.525+00	8.133+00	9.000-01
3.082-04	5.259-02	3.714-05	2.907+03	2.289-01	4.717-01	5.453-01	1.411+01	1.911+00	2.797+01	9.000-01
1.591-03	4.667-02	4.018-05	3.011+03	2.562-01	4.722-01	5.453-01	1.411+01	2.512+00	1.255+02	9.000-01
7.221-03	4.576-02	4.071-05	3.028+03	2.610-01	4.723-01	5.453-01	1.411+01	3.139+00	5.106+02	9.000-01
2.074-02	4.636-02	4.036-05	3.017+03	2.578-01	4.722-01	5.453-01	1.411+01	3.613+00	7.297+02	9.000-01
4.453-02	4.883-02	4.009-05	3.008+03	2.554-01	4.722-01	5.453-01	1.411+01	4.061+00	7.444+02	9.000-01
5.822-02	4.645-02	4.031-05	3.015+03	2.573-01	4.722-01	5.453-01	1.411+01	4.174+00	5.819+02	9.000-01
1.119-01	4.586-02	4.065-05	3.026+03	2.605-01	4.723-01	5.453-01	1.411+01	4.233+00	0.000	9.000-01

DISTANCE FROM WALL, METERS

0.000	3.128-06	8.866-06	3.188-05	9.081-05	3.082-04	1.591-03	7.221-03	2.074-02	4.453-02
5.822-02	1.119-01								

ELEMENTAL FRACTIONS AND THEIR FIRST AND SECOND DERIVATIVES WITH RESPECT TO ETA

H	1.429-01	1.429-01	1.429-01	1.429-01	1.429-01	1.429-01	1.429-01	1.429-01	1.429-01
	1.429-01	1.429-01							
	-1.166-08	-2.534-06	3.031-07	6.082-07	7.524-08	-1.484-08	-1.617-08	-2.088-08	-4.202-08
	-5.445-08	0.000							
	-3.015-04	2.322-04	8.467-06	-7.474-06	-4.102-07	-1.178-09	-1.007-09	-1.872-09	-8.484-10
O	2.410-09	-1.786-10							
	8.571-01	8.571-01	8.571-01	8.571-01	8.571-01	8.571-01	8.571-01	8.571-01	8.571-01
	1.166-08	2.534-06	-3.031-07	-6.082-07	-7.524-08	1.484-08	1.617-08	2.088-08	4.202-08
	5.445-08	0.000							
	3.015-04	-2.322-04	-8.467-06	7.474-06	4.102-07	1.178-09	1.007-09	1.872-09	8.484-10

MOLE FRACTIONS

H	3.931-27	1.584-21	1.284-16	2.147-11	7.537-09	3.089-07	3.578-06	5.223-06	4.064-06	3.351-06
	3.918-06	5.014-06								
	1.000-30	1.000-30	8.372-36	5.028-24	2.730-18	1.163-14	2.862-12	6.694-12	3.810-12	2.471-12
O2	3.510-12	6.115-12								
	1.000-30	1.000-30	2.195-35	9.611-24	4.575-18	1.809-14	4.255-12	9.885-12	5.651-12	3.678-12
	5.210-12	9.037-12								
H2	2.443-01	2.443-01	2.443-01	2.443-01	2.443-01	2.443-01	2.443-01	2.443-01	2.443-01	2.443-01
	2.443-01	2.443-01								
	1.852-34	3.226-27	7.113-21	3.989-14	7.666-11	9.144-09	2.129-07	3.460-07	2.507-07	1.958-07
H2O	2.193-07	3.286-07								
	7.557-01	7.557-01	7.557-01	7.557-01	7.557-01	7.557-01	7.557-01	7.557-01	7.557-01	7.557-01
	7.557-01	7.557-01								

NEW CONTOUR INFORMATION

STATION NO.	DISPLACEMENT THICKNESS METERS	INPUT INVISCID CONTOUR		INPUT WALL CONTOUR	
		NEW WALL CONTOUR-NORM. BY THROAT RADIUS= .13074+00 METERS	NEW INVISCID CONTOUR-NORM. BY THROAT RADIUS= .13102+00 METERS	AXIAL COORDINATE	RADIAL COORDINATE
1	2.47580-05	-2.71987+00	1.73410+00	-2.71418+00	1.73001+00
2	2.28439-05	-2.16052+00	1.73405+00	-2.15601+00	1.73005+00
3	3.01886-05	-2.08632+00	1.73253+00	-2.08197+00	1.72842+00
4	3.75332-05	-2.01210+00	1.72783+00	-2.00793+00	1.72362+00
5	3.65447-05	-1.93789+00	1.71987+00	-1.93390+00	1.71569+00
6	3.55562-05	-1.86367+00	1.70866+00	-1.85986+00	1.70452+00
7	3.45677-05	-1.78946+00	1.69415+00	-1.78583+00	1.69006+00
8	3.35792-05	-1.71525+00	1.67624+00	-1.71179+00	1.67221+00
9	3.25907-05	-1.64104+00	1.65483+00	-1.63775+00	1.63087+00
10	3.16022-05	-1.56683+00	1.62978+00	-1.56371+00	1.62589+00
11	2.41454-05	-1.49263+00	1.60088+00	-1.48966+00	1.59716+00
12	1.66886-05	-1.41845+00	1.56795+00	-1.41560+00	1.56442+00
13	9.23178-06	-1.34426+00	1.53265+00	-1.34153+00	1.52929+00
14	1.77492-06	-1.27009+00	1.49734+00	-1.26746+00	1.49416+00
15	-5.68185-06	-1.19591+00	1.46203+00	-1.19339+00	1.45902+00
16	-1.26734-05	-1.12173+00	1.42672+00	-1.11932+00	1.42389+00
17	-1.96650-05	-1.04755+00	1.39141+00	-1.04525+00	1.38875+00
18	-2.66565-05	-9.73369-01	1.35610+00	-9.71178-01	1.35361+00
19	-3.36562-05	-8.99189-01	1.32079+00	-8.97109-01	1.31847+00
20	-4.06560-05	-8.25010-01	1.28548+00	-8.23040-01	1.28333+00
21	-4.80653-05	-7.50831-01	1.25017+00	-7.48969-01	1.24820+00
22	-5.54747-05	-6.76653-01	1.21486+00	-6.74899-01	1.21306+00
23	-6.28840-05	-6.02474-01	1.17955+00	-6.00828-01	1.17793+00
24	-7.02934-05	-5.28296-01	1.14424+00	-5.26758-01	1.14279+00
25	-7.61801-05	-4.54112-01	1.10894+00	-4.52692-01	1.10765+00
26	-8.20668-05	-3.79918-01	1.07528+00	-3.78636-01	1.07416+00
27	-8.75104-05	-3.05686-01	1.04817+00	-3.04620-01	1.04722+00
28	-9.29541-05	-2.31445-01	1.02745+00	-2.30612-01	1.02665+00
29	-1.02018-04	-1.57203-01	1.01269+00	-1.56605-01	1.01208+00
30	-1.23946-04	-3.38709-02	1.00068+00	-3.36544-02	1.00046+00
31	-1.38085-04	0.00000	1.00000+00	0.00000	1.00000+00
32	-1.43850-04	7.31943-03	1.00002+00	7.28355-03	1.00011+00
33	-1.49777-04	1.44557-02	1.00019+00	1.47599-02	1.00037+00

OUTPUT DELETED

388	6.64146-03	2.16507+01	8.66456+00	2.16172+01	8.54565+00
389	6.84597-03	2.20762+01	8.71496+00	2.20416+01	8.59277+00
390	6.98982-03	2.25108+01	8.76324+00	2.24749+01	8.63900+00
391	7.09634-03	2.29547+01	8.80996+00	2.29174+01	8.68364+00
392	7.22542-03	2.34076+01	8.85502+00	2.33690+01	8.72658+00
393	7.26236-03	2.35373+01	8.86750+00	2.34981+01	8.73844+00

8.2 SAMPLE CASE 2 — AIR FLOW IN A NOZZLE

This sample problem illustrates the homogeneous gas option ($KR(7) = 3$) and the Cebeci turbulent model with variable turbulent Prandtl number. The input data was taken from JPL data for air flow in a conical nozzle (Reference 32). Figure 8-2 shows the nozzle contour and the pressure distribution. (BLIMP predictions for this data are presented in References 18 and 33.) The input is in English engineering units ($KR(13) = 1$) and no namelists are used.

The thermodynamic data cards for air were entered as two sets of cards for N_2 and O_2 to illustrate the input for a mixture of gases. Alternately, a species AIR can be created and only one species entered. In this case the curve fit constants for C_p , h , and s can be easily obtained by curve fitting any set of tabulated values. The expressions for viscosity and Prandtl number were obtained in this manner.

A list of the input data and samples of the output are presented in the following pages. The run time for this problem was on a Univac 1108, EXEC 8 system was 120 system seconds.

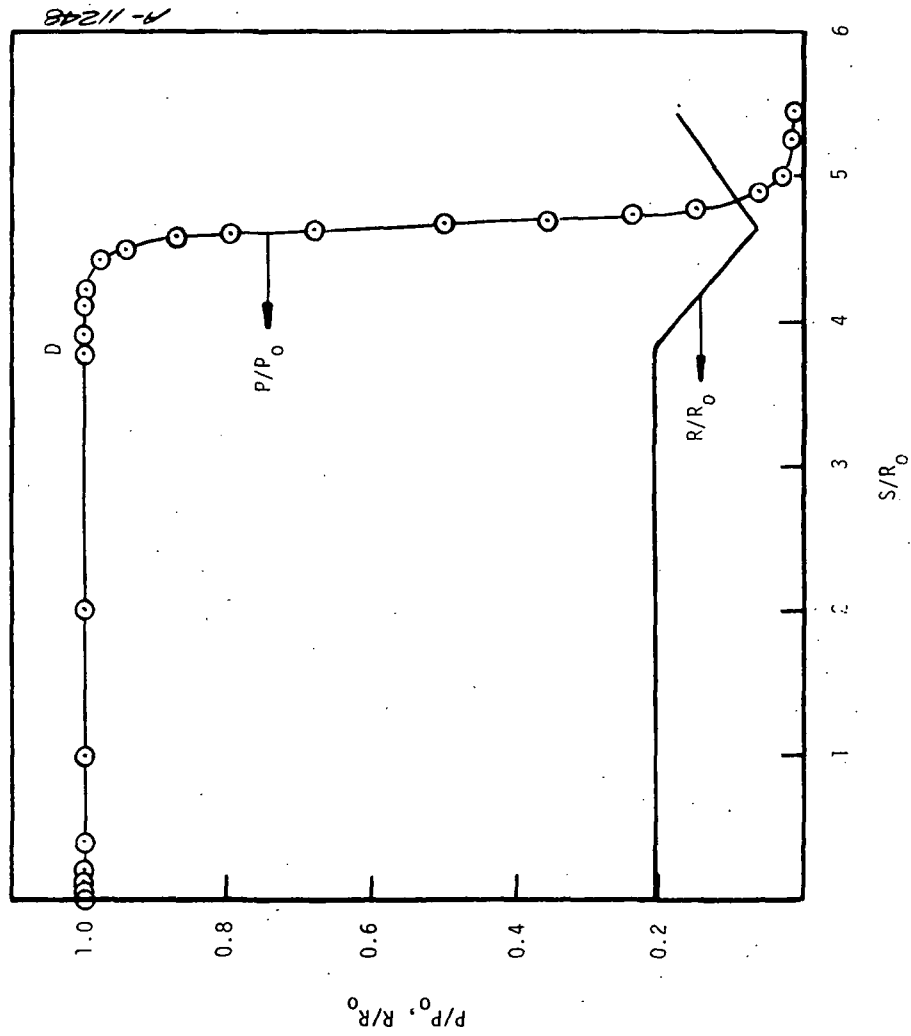


Figure 8-2. Pressure distribution and nozzle contour, sample case 2,
 $(R_0 = 0.304 \text{ m}, P_0 = 1.034 \times 10^6 \text{ N/m}^2)$.

8.2.1 Sample Case 2, Input

10100430110212000000 JPL AIR FLOW, SAMPLE CASE 2--CERECI MODEL										
1.	1	0.01	0.05	0.1	0.2	0.4	1.0	2.0	01100	J
2.	24	3.761	3.917	4.107	4.234	4.361	4.488	2.0	02100	J
3.	4	4.609	4.633	4.647	4.676	4.720	4.781	4.575	03100	J
4.	5	5.063	5.258	5.374				4.907	03201	J
5.	13	0.0	0.002	0.006	0.01	0.025	0.06	0.15	03202	J
6.	9	0.4	0.7	1.0	1.5	2.5	4.0		03203	J
7.	10	0.05	1.3	.5					03204	J
8.	11	0.0	0.05	0.12	0.25	0.35	0.45	0.6	04100	J
9.	12	0.75	0.875	0.95	0.985	0.99	1.0		04201	J
10.	13	1.0							04202	J
11.	14	.20833	.20833	.20833	.20833	.20833	.20833	.20833	04300	J
12.	15	.20833	.1925	.1592	.1374	.1153	.09325	.07833	04401	J
13.	16	.07233	.06817	.06665	.06708	.0745	.08517	.10708	04402	J
14.	17	.134	.1685	.189					05100	J
15.	18	10.21							05201	J
16.	19	240.97							05202	J
17.	20	0.0							05203	J
18.	21	0.4	-11.8	.0168	.9	-.44			05204	J
19.	22	36.74							07100	J
20.	23	.79476	-1.7812-04	1.0	7.78467-08	2.0			07200	J
21.	24	.74-06	1.5	1.0	198.				07300	J
22.	25	2.201	100.	1000.	5000.				08100	J
23.	26	.233	32.	.767	28.01				09600	J
24.	27	02 COLD AIR	NONE	0	2	G 100.	5000.		10100	J
25.	28	3.53							10200	J
26.	29	-1059.09	6.06489	3.53					10300	J
27.	30	N2 COLD AIR	NONE	N	2	G 100.	5000.		10401	J
28.	31	3.51515								
29.	32	-1054.545	6.08115	3.51515	-1054.545	6.08115				
30.	33	0.9972	0.9972	0.9972	0.9972	0.9972	0.9972	0.9972	15101	J
31.	34	0.9972	0.99635	0.99257	0.98703	0.9740	0.93704	0.8659	15102	J
32.	35	0.7887	0.6768	0.4987	0.3512	0.2317	0.1489	0.05927	15102	J
33.	36	0.02767	0.016555	0.01211						
34.	37									
35.	38									
36.	39									
37.	40									
38.	41									
39.	42									
40.	43									
41.	44									
42.	45									
43.	46									
44.	47									
45.	48									
46.	49									
47.	50									
48.	51									
49.	52									
50.										
51.										
52.										

8.2.2 Sample Case 2, Output

JANNAF BOUNDARY LAYER INTEGRAL MATRIX PROCEDURE

BLIMP-J MOD 2 JULY 1975

ACUREX CORP. AEROTHERM DIV., MT. VIEW, CALIF. 20 JUN 75 14:32:07

CASE JPL AIR FLOW, SAMPLE CASE 2--CEBECI MODEL 01100 J

CONTROL NUMBERS 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20

1 0 1 0 0 4 3 0 1 1 0 2 1 2 0 0 0 0 0 0

ETA VALUES

U/UE TO NODAL PT.
NORM. ETA AT WHICH
ETA NORM.

9.500-01 0.000 2.000-03 6.000-03 1.000-02 2.500-02 6.000-02 1.500-01 4.000-01 7.000-01
1.000+00 1.500+00 2.500+00 4.000+00

CASE 1.000000+00

TOTAL ENTHALPY, B/LB 2.40970+02

TOTAL PRESSURE, ATM 1.02100+01

INCID. RAD FLUX, B/SF2 0.00000

CEBECI-SMITH TURB. MODEL

MIXING LENGTH CONSTANT = 4.0000-01
SUBLAYER CONSTANT, YAP = 1.1800+01
CLAUSER NUMBER = 1.6800-02

VARIABLE TURB. PR IN USE
TURBULENT PR CONSTANT = 4.4000-01

TURBULENT SCHMIDT NUMBER = 9.0000-01
TRANSITION MOM. THICK. RE = 0.0000

CASE 1. 20 JUN 75 14:32:07

VISCOSITY LAW MU=(.740-06+T** .150+01)/(.100+01+T* .198+03)

PRANDTL NUMBER PRE .795+00+ -.178-03+T** .100+01+ .778-07+T** .200+01

TEMP. IN DEG. R VISCOSITY IN LB/M-S-FT

MIXTURE CURVE FIT CONSTANTS (DEG K)

100.00	.35182692+01	.00000000	.00000000	.00000000	-.10554997+04	.60777345+01
1000.00	.35182692+01	.00000000	.00000000	.00000000	-.10554997+04	.60777345+01

FLUID MIXTURE

COMPONENT	MOLE FRACTION	MASS FRACTION
O2 COLD AIR	.2101+00	.2330+00
N2 COLD AIR	.7899+00	.7670+00

MOLECULAR WEIGHT = 28.8481004

STAGNATION SOLUTION EDGE CONDITIONS

TEMPERATURE =	.1534+04 DEG R
PRESSURE =	.1021+02 ATMOSPHERES
GAMMA =	.1397+01
ENTHALPY =	.2410+03 BTU/LBM
ENTROPY =	.1894+01 BTU/LBM-DEG R
CP-FROZEN =	.2423+00 BTU/LBM-DEG R
DENSITY =	.2628+00 LBM/FT3
VISCOSITY =	.2567-04 LBM/S-FT

EDGE CONDITIONS

IS	WALL LENGTH FEET	TEMP DEG-R	CP FROZEN B/LB-R	STATIC PRESSURE ATM	DENSITY LB/FS	VISCOSITY LB/FS	VELOCITY F/S	ENTHALPY B/LB	ENTROPY B/LB-R	MACH NO.
1	1.000-02	1.533+03	2.423-01	1.018+01	2.623-01	2.566-05	1.218+02	2.407+02	1.894+00	6.337-02
2	5.000-02	1.533+03	2.423-01	1.019+01	2.623-01	2.566-05	1.218+02	2.407+02	1.894+00	6.337-02
3	1.000-01	1.533+03	2.423-01	1.018+01	2.623-01	2.566-05	1.218+02	2.407+02	1.894+00	6.337-02
4	2.000-01	1.533+03	2.423-01	1.018+01	2.623-01	2.566-05	1.218+02	2.407+02	1.894+00	6.337-02
5	4.000-01	1.533+03	2.423-01	1.019+01	2.623-01	2.566-05	1.218+02	2.407+02	1.894+00	6.337-02
6	1.000+00	1.533+03	2.423-01	1.018+01	2.623-01	2.566-05	1.218+02	2.407+02	1.894+00	6.337-02
7	2.000+00	1.533+03	2.423-01	1.018+01	2.623-01	2.566-05	1.218+02	2.407+02	1.894+00	6.337-02
8	3.761+00	1.533+03	2.423-01	1.018+01	2.623-01	2.566-05	1.218+02	2.407+02	1.894+00	6.337-02
9	3.917+00	1.533+03	2.423-01	1.017+01	2.622-01	2.566-05	1.391+02	2.406+02	1.894+00	7.237-02
10	4.107+00	1.531+03	2.423-01	1.013+01	2.614-01	2.564-05	1.986+02	2.402+02	1.894+00	1.034-01
11	4.234+00	1.529+03	2.423-01	1.008+01	2.604-01	2.562-05	2.626+02	2.396+02	1.894+00	1.368-01
12	4.361+00	1.523+03	2.423-01	9.945+00	2.579-01	2.556-05	3.727+02	2.382+02	1.894+00	1.946-01
13	4.488+00	1.506+03	2.423-01	9.567+00	2.509-01	2.538-05	5.839+02	2.382+02	1.894+00	3.065-01
14	4.575+00	1.473+03	2.423-01	8.841+00	2.371-01	2.503-05	8.640+02	2.261+02	1.894+00	4.587-01
15	4.609+00	1.434+03	2.423-01	8.053+00	2.218-01	2.463-05	1.102+03	2.167+02	1.894+00	5.929-01
16	4.633+00	1.373+03	2.423-01	6.910+00	1.988-01	2.397-05	1.398+03	2.019+02	1.894+00	7.688-01
17	4.647+00	1.259+03	2.423-01	5.092+00	1.597-01	2.269-05	1.828+03	1.743+02	1.894+00	1.049+00
18	4.676+00	1.140+03	2.423-01	3.586+00	1.243-01	2.128-05	2.189+03	1.453+02	1.894+00	1.321+00
19	4.720+00	1.013+03	2.423-01	2.366+00	9.228-02	1.970-05	2.516+03	1.195+02	1.894+00	1.611+00
20	4.781+00	8.930+02	2.423-01	1.520+00	6.725-02	1.810-05	2.790+03	8.554+01	1.894+00	1.902+00
21	4.907+00	6.873+02	2.423-01	6.051-01	3.478-02	1.506-05	3.206+03	3.569+01	1.894+00	2.492+00
22	5.063+00	5.535+02	2.423-01	2.825-01	2.016-02	1.282-05	3.450+03	3.270+00	1.894+00	2.988+00
23	5.258+00	4.783+02	2.423-01	1.690-01	1.396-02	1.145-05	3.580+03	-1.495+01	1.894+00	3.335+00
24	5.374+00	4.376+02	2.423-01	1.236-01	1.116-02	1.066-05	3.648+03	-2.481+01	1.894+00	3.553+00

AXIAL DISTANCE, FEET	.0000	.4000+01	.9000+01	.1900+00	.3900+00	.9900+00	.1900+01	.3751+01
	.39062+01	.40933+01	.42184+01	.43434+01	.44685+01	.45542+01	.45877+01	.46113+01
	.46252+01	.46542+01	.46976+01	.47577+01	.48817+01	.50354+01	.52273+01	.53415+01
WALL LENGTH, FEET	.10000+01	.50000+01	.10000+00	.20000+00	.40000+00	.10000+01	.20000+01	.37610+01
	.39170+01	.41070+01	.42340+01	.43610+01	.44880+01	.45750+01	.46090+01	.46330+01
	.46470+01	.46760+01	.47200+01	.47810+01	.49070+01	.50630+01	.52580+01	.53740+01
RADIUS, FEET	.20833+00	.20833+00	.20833+00	.20833+00	.20833+00	.20833+00	.20833+00	.20833+00
	.19250+00	.15920+00	.13740+00	.11530+00	.93250+01	.78330+01	.72330+01	.68170+01
	.66650+01	.67080+01	.74500+01	.85170+01	.10708+00	.13400+00	.16850+00	.18900+00
X1,(LB/S)**2	.35582+06	.17791+05	.35582+05	.71164+05	.14233+04	.35582+04	.71164+04	.13382+03
	.13930+03	.14580+03	.15004+03	.15421+03	.15835+03	.16112+03	.16219+03	.16294+03
	.16336+03	.16416+03	.16528+03	.16682+03	.16960+03	.17228+03	.17539+03	.17725+03
PRESSURE RATIO	.99720+00	.99720+00	.99720+00	.99720+00	.99720+00	.99720+00	.99720+00	.99720+00
	.99635+00	.99257+00	.98703+00	.97400+00	.93704+00	.86590+00	.78870+00	.67680+00
	.49870+00	.35120+00	.23170+00	.14890+00	.59270+01	.27670+01	.16555+01	.12110+01
STATIC PRESSURE, ATM	.10181+02	.10181+02	.10181+02	.10181+02	.10181+02	.10181+02	.10181+02	.10181+02
	.10173+02	.10134+02	.10078+02	.99445+01	.95672+01	.88408+01	.80526+01	.69101+01
	.50917+01	.35858+01	.23657+01	.15203+01	.60515+00	.28251+00	.16903+00	.12364+00
EDGE VELOCITY, F/S	.12179+03	.12179+03	.12179+03	.12179+03	.12179+03	.12179+03	.12179+03	.12179+03
	.13907+03	.19856+03	.26260+03	.37268+03	.58392+03	.86405+03	.11021+04	.13983+04
	.18277+04	.21886+04	.25163+04	.27898+04	.32061+04	.34500+04	.35798+04	.36480+04
BETAV	.20045+07	.93963+08	.36019+07	.70472+08	.21142+07	.44045+07	.62642+07	.11780+06
	.11573+02	.17441+02	.20911+02	.27354+02	.32436+02	.58084+02	.67985+02	.18631+03
	.15387+03	.42839+02	.28095+02	.18255+02	.13081+02	.56804+01	.23652+01	.35102+01
BETAP	.20045+07	.93963+08	.36019+07	.70472+08	.21142+07	.44045+07	.62642+07	.11780+06
	.11573+02	.17441+02	.20911+02	.27354+02	.32436+02	.58084+02	.67985+02	.18631+03
	.15387+03	.42839+02	.28095+02	.18255+02	.13083+02	.56804+01	.23652+01	.35102+01
INCID RAD.FLUX, B/SF2	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000
	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000
	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000
WALL TEMPERATURE,DEGR	.69000+03	.69000+03	.69000+03	.69000+03	.69000+03	.69000+03	.69000+03	.69000+03
	.69100+03	.70700+03	.72400+03	.73300+03	.77500+03	.82300+03	.84200+03	.81000+03
	.80800+03	.78900+03	.78200+03	.75800+03	.72600+03	.69300+03	.66000+03	.64900+03
MASS FLUX, LB/SF2	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000
	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000
	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000

STATION 1 - - - - - AXIAL POSITION .0000 FEET - - - - -20 JUN 75 14:32:07

ITERATED VALUES DAMP MAX.LIN MAX.ERRORS IN CONSERVATION EQS.

ITS	TIME	ALPH	FWPW	ERROR	MOMENTUM	ENERGY
1	2.936	4.169	.6305	7.00	15	-4.6+00 12 -2.5+02
2	3.497	4.382	.54551	4.00	15	-2.0+00 12 -1.0+02
3	4.047	4.387	.54441	1.07	14	-1.3+01 11 -6.6+00
4	4.600	4.376	.54261	1.07	12	-3.2+02 9 -1.0+00
5	5.155	4.376	.54251	2.07	12	-2.0+03 9 -6.3+02

ALPHA	RADIUS	PRESSURE	EDGE VEL.	BETAP	BETAV	HEAT FLUXES--8/SF2	QCOND
4.376+00	2.083+01	1.018+01	1.218+02	0.000	0.000	3.357+01	3.357+01

WALL MASS FLUXES LB/SF2 CHAR TOTAL GAS ELEMENTAL MASS DIFFUSIVE FLUXES LB/SF2 FOR

8HEAR	MECHANICAL	REMOVAL	PYROL	GAS	CHAR	TOTAL GAS	ELEMENTAL MASS DIFFUSIVE FLUXES LB/SF2 FOR
5.437+01	0.000	0.000	0.000	0.000	0.000	0.000	

MOM TRANS HEAT TRANS BLOWING PARAMETERS ELEMENTAL MASS TRANSFER COEFFICIENTS,

COEFF,	COEFF,	(NORM. BY RHOE*UE*ST) FOR	CHAR	TOTAL GAS	CM, FOR
4.496+03	5.134+03	0.000	0.000	0.000	0.000

MOMENTUM DISPLAC.: EFFECTIVE ENTHALPY REYNOLDS MASS THICKNESS FOR

THICKNESS, THICKNESS,	BODY	THICKNESS, NUMBER	FEET	FEET
8.935+05	7.267+05	1.023+04	1.245+06	0.000

TOTAL HEAT THRUST TOTAL ACCELERATION INVISCID TOTAL MASS IN BL

TO WALL	LOSS	WALL AREA	PARAMETER-K	MASS IN BL
0.000	-2.036+00	0.000	0.000	8.499+02

NODAL INFORMATION

ETA	DISTANCE	F	U/UE	FPP	SHEAR	G, TOTAL	GP	GPP	STATIC	TEMP
0.000	0.000	0.000	0.000	5.425+01	5.437+01	3.635+01	8.986+01	8.986+01	3.635+01	6.900+02
2.000+03	5.004+07	2.078+05	4.750+03	5.432+01	5.437+01	3.713+01	8.995+01	1.012+01	3.713+01	6.932+02
6.000+03	1.508+06	1.872+04	1.427+02	5.446+01	5.437+01	3.871+01	9.013+01	1.014+01	3.871+01	6.998+02
1.000+02	2.525+06	5.205+04	2.381+02	5.460+01	5.437+01	4.029+01	9.031+01	9.846+00	4.029+01	7.063+02
2.500+02	6.424+06	3.263+03	5.981+02	5.510+01	5.437+01	4.624+01	9.095+01	6.222+00	4.623+01	7.308+02
6.000+02	1.604+05	1.890+02	1.445+01	5.554+01	5.431+01	6.024+01	9.190+01	-1.753+01	6.023+01	7.886+02
1.500+01	4.608+05	1.165+01	3.453+01	4.643+01	5.339+01	9.507+01	8.500+01	-3.863+01	9.504+01	9.322+02
4.000+01	1.428+04	7.130+01	6.912+01	1.680+01	4.448+01	1.649+02	4.274+01	-1.520+01	1.648+02	1.220+03
7.000+01	2.858+04	1.743+00	8.604+01	8.977+02	2.947+01	2.079+02	2.278+01	-9.190+00	2.077+02	1.397+03
1.000+00	4.438+04	2.937+00	9.500+01	4.678+02	1.390+01	2.299+02	1.072+01	-5.073+00	2.297+02	1.488+03
1.500+00	7.178+04	5.090+00	1.000+00	-6.505+04	-1.617+03	2.412+02	-3.809+01	1.343+01	2.410+02	1.534+03
2.500+00	1.272+03	9.464+00	9.998+01	3.629+04	6.535+04	2.409+02	2.070+01	-1.119+01	2.406+02	1.533+03
4.000+00	2.104+03	1.603+01	1.000+00	0.000	0.000	2.410+02	0.000	4.882+02	2.407+02	1.533+03

DISTANCE FROM WALL		DENSITY	VISCOSITY		SPECIFIC	THERMAL	PRANDTL	MODIFIED	MOLECULAR	MACH	PHOSQ*EPS	TURBULENT
FEET		RHO	MU	LB/FS	HEAT	COND.	NUMBER	SCHMIDT	WEIGHT	NUMBER	/RHOF*MUE	PRANDTL NO
		LB/F3			B/LB-R	B/SF-R		NUMBER				
0.000	5.829-01	1.510-05	2.423-01	5.163-06	7.089-01	7.089-01	7.089-01	2.885+01	0.000	0.000	0.000	
5.004-07	5.801-01	1.516-05	2.423-01	5.182-06	7.087-01	7.087-01	7.087-01	2.885+01	3.438-08	4.478-04	1.498+00	
1.508-06	5.748-01	1.526-05	2.423-01	5.220-06	7.082-01	7.082-01	7.082-01	2.885+01	2.690-06	1.339-03	1.497+00	
2.525-06	5.694-01	1.536-05	2.423-01	5.259-06	7.078-01	7.078-01	7.078-01	2.885+01	2.005-05	2.224-03	1.496+00	
6.424-06	5.503-01	1.574-05	2.423-01	5.401-06	7.062-01	7.062-01	7.062-01	2.885+01	6.910-04	5.491-03	1.492+00	
1.604-05	5.100-01	1.661-05	2.423-01	5.728-06	7.027-01	7.027-01	7.027-01	2.885+01	1.724-02	1.277-02	1.483+00	
4.408-05	4.314-01	1.864-05	2.423-01	6.485-06	6.964-01	6.964-01	6.964-01	2.885+01	3.061-01	2.807-02	1.463+00	
1.428-04	3.296-01	2.224-05	2.423-01	7.773-06	6.933-01	6.933-01	6.933-01	2.885+01	2.365+00	4.911-02	1.405+00	
2.858-04	2.878-01	2.423-05	2.423-01	8.413-06	6.979-01	6.979-01	6.979-01	2.885+01	3.248+00	5.712-02	1.334+00	
4.430-04	2.703-01	2.519-05	2.423-01	8.695-06	7.021-01	7.021-01	7.021-01	2.885+01	2.864+00	6.112-02	1.268+00	
7.178-04	2.621-01	2.567-05	2.423-01	8.828-06	7.047-01	7.047-01	7.047-01	2.885+01	2.244+00	6.338-02	1.174+00	
1.272-03	2.624-01	2.566-05	2.423-01	8.823-06	7.046-01	7.046-01	7.046-01	2.885+01	1.349+00	6.338-02	1.042+00	
2.104-03	2.623-01	2.566-05	2.423-01	8.825-06	7.047-01	7.047-01	7.047-01	2.885+01	0.000	6.338-02	9.452-01	

REFIT CALLED

I	ETA(I)	U/UE	G(I,I)	SP(1,I,1)	SP(1,I,2)	SP(1,I,3)	SP(1,I,4)	SP(1,I,5)	SP(1,I,6)	SP(1,I,7)	SP(1,I,8)
1	0.000	0.000	3.635+01	1.000+00							
2	2.092-02	4.996-02	4.461+01	0.000							
3	4.989-02	1.201-01	5.619+01	0.000							
4	1.053-01	2.501-01	7.811+01	0.000							
5	1.523-01	3.497-01	9.590+01	0.000							
6	2.054-01	4.504-01	1.146+02	0.000							
7	3.067-01	5.985-01	1.441+02	0.000							
8	4.857-01	7.523-01	1.801+02	9.000-02							
9	7.384-01	8.748-01	2.117+02	1.667-01							
10	1.000+00	9.500-01	2.299+02	0.000							
11	1.220+00	9.856-01	2.380+02	0.000							
12	1.269+00	9.891-01	2.388+02	0.000							
13	4.000+00	1.000+00	2.410+02	-1.000+00							

OUTPUT DELETED

DISTANCE FROM WALL FEET	DENSITY RHO LB/FT ³	VISCOSITY MU LB/FT ²	SPECIFIC HEAT B/LB-R	THERMAL COND. B/FT-R	PRANDTL NUMBER	MODIFIED SCHMIDT NUMBER	MOLECULAR WEIGHT	MACH NUMBER	RHOSQ*EPS /RHO*NU*E	TURBULENT PRANDTL NO
0.000	7.526+01	1.444+05	2.423+01	4.916+06	7.119+01	7.119+01	2.885+01	0.000	0.000	0.000
1.718+05	7.307+01	1.476+05	2.423+01	5.034+06	7.105+01	7.105+01	2.885+01	1.297+01	3.830+04	1.399+00
4.222+05	7.072+01	1.511+05	2.423+01	5.166+06	7.089+01	7.089+01	2.885+01	3.077+01	1.093+02	1.386+00
9.660+05	6.823+01	1.551+05	2.423+01	5.315+06	7.071+01	7.071+01	2.885+01	6.419+01	1.831+01	1.358+00
1.582+04	6.796+01	1.555+05	2.423+01	5.331+06	7.070+01	7.070+01	2.885+01	9.253+01	7.349+01	1.327+00
2.684+04	6.982+01	1.525+05	2.423+01	5.219+06	7.083+01	7.083+01	2.885+01	1.241+00	2.534+00	1.269+00
6.305+04	7.749+01	1.414+05	2.423+01	4.802+06	7.134+01	7.134+01	2.885+01	1.747+00	1.308+01	1.108+00
2.080+03	9.551+01	1.206+05	2.423+01	4.037+06	7.240+01	7.240+01	2.885+01	2.451+00	6.725+01	9.152+01
8.171+03	1.232+02	9.829+06	2.423+01	3.235+06	7.364+01	7.364+01	2.885+01	3.306+00	2.961+02	9.091+01
2.285+02	1.250+02	9.711+06	2.423+01	3.193+06	7.370+01	7.370+01	2.885+01	3.572+00	3.048+02	9.091+01
4.789+02	1.143+02	1.045+05	2.423+01	3.455+06	7.329+01	7.329+01	2.885+01	3.556+00	1.614+02	9.091+01
5.363+02	1.133+02	1.053+05	2.423+01	3.484+06	7.324+01	7.324+01	2.885+01	3.554+00	1.382+02	9.091+01
9.345+02	1.116+02	1.066+05	2.423+01	3.530+06	7.317+01	7.317+01	2.885+01	3.553+00	0.000	9.091+01

8.3 SAMPLE CASE 3 — BINARY DIFFUSION EXAMPLE

This sample problem illustrates the deck setup for the binary diffusion option. The propellant and wall materials are discussed in Section 6.4. The appropriate elemental composition of the edge gas, the char material and the dummy species are shown in the Groups 11 and 13 input. A fairly complete species deck for the H-C-N-O gas system is retained. The effect of this large number of species on the computation time can be seen by comparing the time per iteration for this problem with that of Sample case 8.1. The time per iteration is about 3 seconds,* of which about 1 second is for the boundary layer iteration and about 2 seconds are for the chemistry iteration. This same problem required approximately 2 seconds more per iteration when the binary diffusion option was not used. (The total run time for 27 stations is about 600 seconds.)

This problem is similar to the type encountered in solid propellant nozzles. It has been assumed that the boundary condition for the wall material (MX4926, carbon phenolic tape) can be modeled as a steady-state energy balance ($KR(9) = 4$). Basically, this means that all of the heat to the wall is used to ablate the wall material and that none (or very little) is removed from the outer surface of the nozzle.

The pressure distribution and nozzle contour are shown in Figure 8-3. The stagnation conditions are:

$$P_0 = 6.89286 \times 10^6 \text{ N/m}^2 \text{ (1000 psia)}$$

$$T_0 = 3880^\circ\text{K} \text{ (} H_0 = 34518 \times 10^6 \text{ J/kg)}$$

For solid propellants which contain solid Al_2O_3 after combustion it is necessary to remove the solids from the elemental composition of the edge gas. Usually this is done by removing all the Al and the necessary mass of O used to form Al_2O_3 .

*Seconds as used here refer to Univac 1108 Exec 8 system seconds.

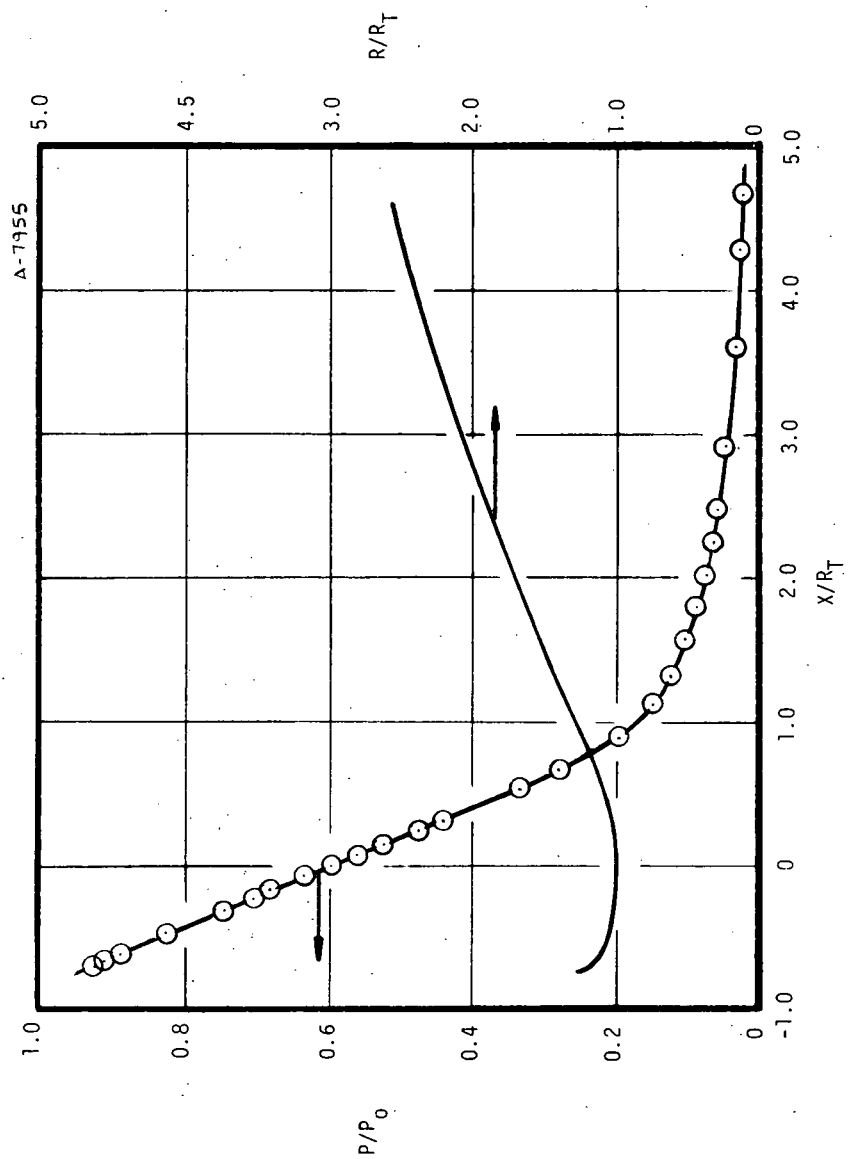


Figure 8-3. Pressure distribution and nozzle contour, sample case 3, ($R_T = 0.674$ m, $P_0 = 4.134 \times 10^6$ N/m²).

8.3.1 Sample Case 3, Input
1; 30200620410202000100 SOLID PROPELLANT SAMPLE CASE 3--BINARY DIFF. 01100 S

8-31

53.	0.31001901E 01 0.51119464E-03 0.52644210E-07 0.34909973E-10 0.36945345E-14	2
54.	-0.87738042E 03 0.19629421E 01 0.30574451E 01 0.26765200E-02 0.58099162E-05	3
55.	0.55210391E-08 0.18122739E-11 0.98890474E 03 0.22997056E 01	4
56.	CO J 9/65C 10 100 000 0G 300.000 5000.000	1
57.	0.29840696E 01 0.14891390E-02 0.57899684E-06 0.10364577E-09 0.69353550E-14	2
58.	-0.14245228E 05 0.63479156E 01 0.37100928E 01 0.16190964E-02 0.36923594E-05	3
59.	-0.20319674E-08 0.23953344E-12 0.14356310E 05 0.29555351E 01	4
60.	C(9) J 3/61C 10 00 00 0G 300.000 5000.000	1
61.	0.13604942E 01 0.19182377E-02 0.84040389E-06 0.16448707E-09 0.11672670E-13	2
62.	-0.65713870E 03 0.8007207E 01 0.44778053E 01 0.53691002E-02 0.39775571E-06	3
63.	-0.40459298E-08 0.21134939E-11 0.94280688E 02 0.16840791E 01	4
64.	C J 3/61C 100 000 000 0G 300.000 5000.000	1
65.	0.25810663E 01 0.14692602E-03 0.74388084E-07 0.79481079E-11 0.58900977E-16	2
66.	0.85216294E 05 0.43128879E 01 0.25328705E 01 0.15887641E-03 0.30682082E-06	3
67.	-0.26770064E-09 0.87488827E-13 0.85240422E 05 0.46062374E 01	4
68.	C2 J12/69C 20 00 00 0G 300.000 5000.000	1
69.	0.40435359E 01 0.20573654E-03 0.10907575E-06 0.36427874E-10 0.34127865E-14	2
70.	0.99709486E 05 0.12775158E 01 0.74518140E 01 0.10144686E-01 0.85879735E-05	3
71.	0.87321100E-09 0.24429792E-11 0.98911989E 05 0.15846678E 02	4
72.	C3 J12/69C 30 00 00 0G 300.000 5000.000	1
73.	0.36815361E 01 0.24165236E-02 0.84348112E-06 0.14508198E-09 0.95697300E-14	2
74.	0.97413955E 05 0.68377802E 01 0.57408464E 01 0.84281238E-02 0.18620198E-04	3
75.	-0.14510529E-07 0.39676977E-11 0.97157524E 05 0.23837376E 01	4
76.	C4 J12/69C 40 00 00 0G 300.000 5000.000	1
77.	0.65602101E 01 0.4085234E-02 0.17000471E-05 0.31615228E-09 0.21842144E-13	2
78.	0.11430434E 06 0.11820311E 02 0.18432021E 01 0.19343592E-01 0.20627502E-04	3
79.	0.10822626E-07 0.21289203E-11 0.11550276E 06 0.12006898E 02	4
80.	C5 J12/69C 50 00 00 0G 300.000 5000.000	1
81.	0.82067016E 01 0.54889888E-02 0.22694876E-05 0.42073365E-09 0.28981924E-13	2
82.	0.11463647E 06 0.20246108E 02 0.11012446E 01 0.29513421E-01 0.33754342E-04	3
83.	0.19056534E-07 0.4089018E-11 0.11637970E 06 0.15360193E 02	4
84.	CH J 6/69C 1H 30 00 0G 300.000 5000.000	1
85.	0.28400327E 01 0.60869086E-02 0.21740338E-05 0.36042576E-09 0.22725300E-13	2
86.	0.16449813E 05 0.55056751E 01 0.34666350E 01 0.38301845E-02 0.10116802E-05	3
87.	-0.18859236E-08 0.66803182E-12 0.16313104E 05 0.24172192E 01	4
88.	CH J 3/61C 1H 400 000 0G 300.000 5000.000	1
89.	0.15027072E 01 0.10416798E-01 0.39181522E-05 0.67777899E-09 0.44283706E-13	2
90.	-0.99787078E 04 0.10707143E 02 0.38261932E 01 0.39794581E-02 0.24558340E-04	3
91.	-0.22732926E-07 0.69626957E-11 0.10144950E 05 0.86690073E 00	4
92.	C2H J 3/67C 2H 100 000 0G 300.000 5000.000	1
93.	0.44207650E 01 0.22119303E-02 0.59294943E-06 0.94195775E-10 0.68527594E-14	2
94.	0.55835444E 05 0.11588093E 01 0.26499400E 01 0.84919515E-02 0.98165375E-05	3
95.	0.65373629E-08 0.17556273E-11 0.56275751E 05 0.76898609E 01	4
96.	C2H2 J 3/61C 2H 200 000 0G 300.000 5000.000	1
97.	0.45751083E 01 0.51238358E-02 0.17452354E-05 0.28673065E-09 0.17951426E-13	2
98.	0.25607428E 05 0.35737940E 01 0.14102768E 01 0.19057275E-01 0.24501390E-04	3
99.	0.16390872E-07 0.41345447E-11 0.26188208E 05 0.11393827E 02	4
100.	C2H4 J 9/65C 2H 400 000 0G 300.000 5000.000	1
101.	0.34552152E 01 0.11491803E-01 0.43651750E-05 0.76155095E-09 0.50123200E-13	2
102.	0.44773119E 04 0.26987959E 01 0.14256821E 01 0.11383140E-01 0.79890006E-05	3
103.	-0.16253679E-07 0.67491256E-11 0.53370755E 04 0.14621819E 02	4
104.	CD2 J 9/65C 10 200 000 0G 300.000 5000.000	1
105.	0.44608041E 01 0.30981719E-02 0.12392571E-05 0.22741325E-09 0.15525954E-13	2
106.	-0.48961442E 05 0.98635982E 00 0.24007797E 01 0.87350957E-02 0.66070878E-05	3
107.	0.20021861E-08 0.63274039E-15 0.48377527E 05 0.96951457E 01	4
108.	HCH 000000H 1C 1N 10 0G 300.000 5000.000	1

109. 0.37068121E 01 0.33382803E-02-0.11913320E-05 0.19992917E-09-0.12826452E-13 2
 110. 0.14962636E 05 0.20790904E 01 0.24513556E 01 0.87208371E-02-0.10094203E-04 3
 111. 0.67255698E-08-0.17626959E-11 0.15213002E 05 0.80830085F 01 4
 112. J 3/61H 20 100 000 0G 300.000 5000.000 1
 113. 0.27167633E 01 0.29451374E-02-0.80224374E-06 0.10226682E-09-0.48472145E-14 2
 114. 0.29905826E 05 0.66305671E 01 0.40701275E 01-0.1108499E-02 0.41521180E-05 3
 115. 0.29637404E-08 0.80702103E-12-0.30279722E 05-0.32270046E 00 4
 116. J 9/65H 100 000 000 0G 300.000 5000.000 1
 117. 0.25000000E 01 0. 0. 0. 0. 0. 2
 118. 0.25471627E 05-0.46011763E 00 0.25000000E 01 0. 0. 3
 119. 0. 0. 0.25471627E 05-0.46011762F 00 4
 120. J 3/61H 1C 100 0G 300.000 5000.000 1
 121. 0.33366720E 01 0.33912031E-02-0.12957629E-05 0.22679230E-09-0.14952372E-13 2
 122. 0.26430557E 04 0.69479829E 01 0.37929190E 01-0.47861919E-04 0.57306920E-05 3
 123. 0.54606603E-08 0.16288628E-11-0.26288218E 04 0.52070412E 01 4
 124. J 3/61H 100 000 000 0G 300.000 5000.000 1
 125. 0.24502682E 01 0.10661458E-03-0.74653373E-07 0.18798524E-10-0.10259839E-14 2
 126. 0.56116040E 05 0.44887581E 01 0.25030714E 01-0.21800181E-04 0.54205287E-07 3
 127. 0.56475602E-10 0.20999044E-13 0.56098904E 05 0.41675764E 01 4
 128. J 6/63N 1C 100 000 0G 300.000 5000.000 1
 129. 0.31890000E 01 0.13322281E-02-0.52899318E-06 0.95919332E-10-0.64847932E-14 2
 130. 0.98283290E 04 0.67458126E 01 0.40459521E 01-0.34181783E-02 0.79819190E-05 3
 131. 0.61139316E-08 0.15919076E-11 0.97453934E 04 0.29974988E 01 4
 132. J 9/65N 20 00 00 0G 300.000 5000.000 1
 133. 0.28963194E 01 0.15154866E-02-0.57235277E-06 0.99807393E-10-0.65223555E-14 2
 134. 0.90586184E 03 0.61615148E 01 0.36748261E 01-0.12081500E-02 0.23240102E-05 3
 135. 0.63217559E-09-0.22577253E-12-0.10611588E 04 0.23580424E 01 4
 136. J12/65N 1H 100 000 0G 300.000 5000.000 1
 137. 0.27741580E 01 0.13179398E-02-0.38379707E-06 0.54142146E-10-0.28838332E-14 2
 138. 0.39959049E 05 0.57923234E 01 0.34089532E 01 0.28026519E-03-0.13456768E-05 3
 139. 0.22935931E-08-0.95737540E-12 0.39714793E 05 0.18654962E 01 4
 140. J12/65N 1H 200 000 0G 300.000 5000.000 1
 141. 0.25769524E 01 0.35860909E-02-0.12276328E-05 0.19549576E-09-0.11873401E-13 2
 142. 0.19335912E 05 0.79074890E 01 0.40385791E 01-0.10098163E-02 0.40120903E-05 3
 143. 0.23085312E-08 0.39022887E-12 0.18973010E 05 0.52464285E 00 4
 144. J 9/65N 1H 300 000 0G 300.000 5000.000 1
 145. 0.24165177E 01 0.61871211E-02-0.21785136E-05 0.37599090E-09-0.24448856E-13 2
 146. 0.64747177E 04 0.77043482E 01 0.35912768E 01 0.49388688E-03 0.83449322E-05 3
 147. 0.83833385E-08 0.27299092E-11-0.66717143E 04 0.22520966E 01 4
 148. J 6/620 100 000 0G 300.000 5000.000 1
 149. 0.25420596E 01-0.27550619E-04-0.31028033E-08 0.45510674E-11-0.23680515E-15 2
 150. 0.29230803E 05 0.49203080E 01 0.29464287E 01-0.16381665E-02 0.24210316E-05 3
 151. 0.16028432E-08 0.38906964E-12 0.29147644E 05 0.29639949E 01 4
 152. J 3/660 1H 100 000 0G 300.000 5000.000 1
 153. 0.29106427E 01 0.95931650E-03-0.19441702E-06 0.13758646E-10-0.14224542E-15 2
 154. 0.39353815E 04 0.54423445E 01 0.38375943E 01-0.10778858E-02 0.96830378E-06 3
 155. 0.18713972E-09-0.22571094E-12 0.36412823E 04 0.49370009E 00 4
 156. J 9/650 20 00 00 0G 300.000 5000.000 1
 157. 0.36219535E 01 0.73618264E-03-0.19652228E-06 0.36201558E-10-0.28945627E-14 2
 158. 0.12019825E 04 0.36150960E 01 0.36255985E 01-0.18782184E-02 0.70554544E-05 3
 159. 0.67635137E-08 0.21555993E-11-0.10475226E 04 0.43052778E 01 4
 160. 13 LAST
 161. 987ALIS
 162. SEND
 163. LAST 9

8.3.2 Sample Case 3, Output

JANNAF BOUNDARY LAYER INTEGRAL MATRIX PROCEDURE

BLIMP-J MOD 2 JULY 1975

ACUREX CORP. AEROTHERM DIV., MT. VIEW, CALIF. 23 JUN 75 07:52:43

CASE SOLID PROPELLANT SAMPLE CASE 3--BINARY DIFF. 01100 8

CONTROL NUMBERS 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20

3 0 2 0 0 6 2 0 4 1 0 2 0 2 0 0 0 1 0 0

ETA VALUES

U/UE TO NODAL PT.
NORM. ETA AT WHICH
ETA NORM. 10

9.500=01 0.000 2.000=03 6.000=03 1.000=02 2.500=02 6.000=02 1.500=01 4.000=01 7.000=01
1.000=00 1.500=00 2.500=00

QUASI-STEADY ENERGY BALANCE AT THE WALL

SURFACE NUMBER	1	2	3
SURFACE EMITTANCE	0.00000	0.00000	0.00000
ENTHALPY OF CHAR AT REF TEMP/J/KG	-8.78000+05	0.00000	0.00000
ENTHALPY OF PYROLYSTS GAS J/KG	0.00000	0.00000	0.00000
EQUILIBRIUM SURFACE SPECIES C(S)			

CASE 1.00000+00

TOTAL ENTHALPY, J/KG 3.45180+06

TOTAL PRESSURE, N/M2 6.89286+06

INCID. RAD FLUX, W/M2 0.00000

KENDALL TURR. MODEL

MIXING LENGTH CONSTANT = 4.4000=01

SUBLAYER CONSTANT, YAP = 1.1823+01

CLAUSER NUMBER = 1.8000=02

TURBULENT PRANDTL NUMBER = 9.0000=01

TURBULENT SCHMIDT NUMBER = 9.0000=01

TRANSITION MOM. THICK. RE = 0.0000

C4	1000.00	J12/69C 4.0	0.0	0.0	0.0	0.0	300.000	5000.000	1.0822626-07	-.21280203-11	.11550276+06	.12006898+02
	5000.00	.18432021+01	.19343592-01	-.20627502-04	-.17000471-05	.00000000	.00000000	.31615228-09	-.21842144-13	.11430434+06	-.11820311+02	.00000000
C5	5000.00	.00000000	.00000000	.00000000	.00000000	.00000000	.00000000	.00000000	.00000000	.00000000	.00000000	.00000000
	1000.00	J12/69C 5.0	0.0	0.0	0.0	0.0	300.000	5000.000	1.09056534-07	.11637970+06	.15360193+02	.00000000
	5000.00	.11012446+01	.29513421-01	-.33754342-04	-.22694876-05	.00000000	.00000000	.42073365-09	-.40989018-11	.11463647+06	-.20246108+02	.00000000
CH3	5000.00	.82067016+01	.54889888-02	.00000000	.00000000	.00000000	300.000	5000.000	-.28981924-13	.00000000	.00000000	.00000000
	1000.00	.00000000	.00000000	.00000000	.00000000	.00000000	.00000000	.00000000	.00000000	.00000000	.00000000	.00000000
	5000.00	J 6/69C 1.H	3.0	0.0	0.0	0.0	.00000000	.00000000	.00000000	.00000000	.00000000	.00000000
CH4	1000.00	.34666350+01	.38301845-02	-.10116802-05	-.21740338-05	.00000000	300.000	5000.000	-.66803182-12	.16313104+05	.24172192+01	.00000000
	5000.00	.28400327+01	.60869086-02	.00000000	.00000000	.00000000	.00000000	.00000000	-.22725300-13	.16449813+05	.55056751+01	.00000000
	5000.00	.00000000	.00000000	.00000000	.00000000	.00000000	.00000000	.00000000	.00000000	.00000000	.00000000	.00000000
	1000.00	J 3/61C 1.H	4.0	0.0	0.0	0.0	300.000	5000.000	-.69626957-11	-.10144950+05	.86690073+00	.00000000
	5000.00	.38261932+01	-.39794581-02	-.24558340-04	-.39181522-05	.00000000	.00000000	.00000000	-.44283706-13	-.99787078+04	.10707143+02	.00000000
	5000.00	.15027072+01	.10416798-01	.00000000	.00000000	.00000000	.00000000	.00000000	.00000000	.00000000	.00000000	.00000000
C2H	1000.00	.00000000	.00000000	.00000000	.00000000	.00000000	300.000	5000.000	.00000000	.00000000	.00000000	.00000000
	5000.00	J 3/67C 2.H	1.0	0.0	0.0	0.0	.00000000	.00000000	.00000000	.00000000	.00000000	.00000000
	5000.00	.26499400+01	.84919515-02	-.98165375-05	-.59294945-06	.00000000	.00000000	.00000000	-.17356273-11	.56275751+05	.76898609+01	.00000000
	1000.00	.44207650+01	.22119303-02	.00000000	.00000000	.00000000	.00000000	.00000000	-.68527594-14	.55835444+05	-.11588093+01	.00000000
C2H2	5000.00	.00000000	.00000000	.00000000	.00000000	.00000000	.00000000	.00000000	.00000000	.00000000	.00000000	.00000000
	1000.00	J 3/61C 2.H	2.0	0.0	0.0	0.0	300.000	5000.000	.00000000	.00000000	.00000000	.00000000
	5000.00	.14102768+01	.19057275-01	-.24501390-04	-.17452354-05	.00000000	.00000000	.00000000	-.41345447-11	.26188208+05	.35737940+01	.00000000
	5000.00	.45751083+01	.51238358-02	.00000000	.00000000	.00000000	.00000000	.00000000	-.17951426-13	.25607428+05	.11393827+02	.00000000
	5000.00	.00000000	.00000000	.00000000	.00000000	.00000000	.00000000	.00000000	.00000000	.00000000	.00000000	.00000000
C2H4	1000.00	J 9/65C 2.H	4.0	0.0	0.0	0.0	300.000	5000.000	.00000000	.00000000	.00000000	.00000000
	5000.00	.14256821+01	.11383140-01	-.79890006-05	-.43651750-05	.00000000	.00000000	.00000000	-.67491256-11	.53370755+04	.14621819+02	.00000000
	5000.00	.34552152+01	.11491803-01	.00000000	.00000000	.00000000	.00000000	.00000000	-.50123200-13	.44773119+04	.26987959+01	.00000000
	5000.00	.00000000	.00000000	.00000000	.00000000	.00000000	.00000000	.00000000	.00000000	.00000000	.00000000	.00000000
C02	1000.00	J 9/65C 1.0	2.0	0.0	0.0	0.0	300.000	5000.000	.00000000	.00000000	.00000000	.00000000
	5000.00	.24007797+01	.87350957-02	-.66070878-05	-.12392571-05	.00000000	.00000000	.00000000	-.63274039-15	-.48377527+05	.96951457+01	.00000000
	5000.00	.44608041+01	.30981719-02	.00000000	.00000000	.00000000	.00000000	.00000000	-.15525954-13	-.48961442+05	-.98635982+00	.00000000
HCN	1000.00	.00000000	.00000000	.00000000	.00000000	.00000000	300.000	5000.000	.00000000	.00000000	.00000000	.00000000
	5000.00	.00000000	.00000000	.00000000	.00000000	.00000000	.00000000	.00000000	.00000000	.00000000	.00000000	.00000000
	5000.00	.00000000	.00000000	.00000000	.00000000	.00000000	.00000000	.00000000	.00000000	.00000000	.00000000	.00000000
	1000.00	.24513556+01	.87208371-02	-.10094203-04	-.11913320-05	.00000000	300.000	5000.000	-.17626959-11	.15213002+05	.80830085+01	.00000000
	5000.00	.37068121+01	.33382803-02	.00000000	.00000000	.00000000	.00000000	.00000000	-.12826452-13	.14962636+05	.20784904+01	.00000000
	5000.00	.00000000	.00000000	.00000000	.00000000	.00000000	.00000000	.00000000	.00000000	.00000000	.00000000	.00000000
H2O	1000.00	J 3/61H 2.0	1.0	0.0	0.0	0.0	300.000	5000.000	.00000000	.00000000	.00000000	.00000000
	5000.00	.40701275+01	.11084499-02	-.41521180-05	-.80224374-06	.00000000	.00000000	.00000000	-.80702103-12	-.30279722+05	.32270046+00	.00000000
	5000.00	.27167633+01	.29451374-02	.00000000	.00000000	.00000000	.00000000	.00000000	-.48472145-14	-.29905826+05	.66305671+01	.00000000
	5000.00	.00000000	.00000000	.00000000	.00000000	.00000000	.00000000	.00000000	.00000000	.00000000	.00000000	.00000000
H	1000.00	J 9/65H 1.00	0.0	0.0	0.0	0.0	300.000	5000.000	.00000000	.00000000	.00000000	.00000000
	5000.00	.25000000+01	.00000000	.00000000	.00000000	.00000000	.00000000	.00000000	.00000000	.25471627+05	.46011762+00	.00000000
	5000.00	.25000000+01	.00000000	.00000000	.00000000	.00000000	.00000000	.00000000	.00000000	.25471627+05	.46011763+00	.00000000
	5000.00	.00000000	.00000000	.00000000	.00000000	.00000000	.00000000	.00000000	.00000000	.00000000	.00000000	.00000000

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ELEMENT	HYDROGEN	CARBON	NITROGEN	OXYGEN
BASE SP	H2	WALL GAS	EDGE GAS	CO

MOLECULAR TRANSPORT PROPERTIES
 VISCOSITY BUDDENBERG = WILKE MIXTURE FORMULA WITH MU(I) CALCULATED ON
 THE BASIS OF D(I,I) = DBAR/G(I)**2
 THERMAL CONDUCTIVITY MASON = SAXENA MIXTURE FORMULA WITH EUCKEN CORRECTION
 DIFFUSION COEFFICIENTS D(I,J) = DBAR/(F(I)*F(J)) WITH DBAR BASED ON
 SIGMA = 3.4670, EPOVRK = 106.7000, AND MREF = 32.0000

METHODS EMPLOYED

0 CONDENSED PHASE, VALUES FOR F(I) AND G(I) SET EQUAL TO 1.E+10
 1 VALUES FOR F(I) (OR G(I)) INPUT DIRECTLY
 2 VALUES FOR F(I) (OR G(I)) CALCULATED BY F(I) = (M(I)/FITMOL)**FFA AND
 G(I) = (M(I)/FITGMW)**GGA WHERE M(I) IS SPECIES MOLECULAR WEIGHT,
 FITMOL = 26.7000, AND FFA = .4890, FITGMW = 24.3000, AND GGA = .4540

SPECIES	F(I)	METHOD	G(I)	METHOD	SPECIES	F(I)	METHOD	G(I)	METHOD
WALL GAS	*****	0	*****	0	EDGE GAS	*****	0	*****	0
H2	.283	2	.323	2	CO	1.024	2	1.066	2
C(S)	*****	0	*****	0	C	.676	2	.726	2
C2	.949	2	.994	2	C3	1.157	2	1.195	2
C4	1.332	2	1.362	2	C5	1.486	2	1.507	2
CH3	.755	2	.804	2	CH4	.779	2	.828	2
C2H	.968	2	1.013	2	C2H2	.987	2	1.031	2
C2H4	1.024	2	1.067	2	CO2	1.277	2	1.309	2
HCN	1.006	2	1.049	2	H2O	.825	2	.873	2
H	.201	2	.236	2	HCO	1.041	2	1.084	2
N	.729	2	.779	2	NO	1.059	2	1.101	2
N2	1.024	2	1.067	2	NH	.755	2	.804	2
NH2	.779	2	.828	2	NH3	.803	2	.851	2
O	.778	2	.827	2	OH	.802	2	.850	2
O2	1.093	2	1.133	2					

STAGNATION SOLUTION FOLLOWED BY BOUNDARY-LAYER EDGE EXPANSION

CP=FROZEN CP=EQUIL GAMMA
 J/KG-K J/KG-K
 .17089+04 .34929+04 .11929+01
 TEMP = 3880.4586 DEG-K PRES = 6.893+06 N/M2 MOL WT = 224.0263128
 ENTHALPY = .3451800+07 J/KG ENTROPY = .10875+05 J/KG-K
 DENSITY = .478549+01 KG/M3
 VEL = 0.000 M/S MACH NO. = 0.000

SPECIES	MOLE FR.	SPECIES	MOLE FR.	SPECIES	MOLE FR.
WALL GAS	1.0000	EDGE GAS	.00000	H2	.13943+00
CO	.39303+00	C(S)	.00000	C	.98618+07
C2	.23246+10	C3	.28092+13	C4	.53595+19
C5	.23528+22	CH3	.59256+07	CH4	.69636+08
C2H	.20850+08	C2H2	.28185+08	C2H4	.76075+12
CO2	.17965+01	HCN	.26634+04	H2O	.53539+01
H	.157907+01	HCD	.29568+03	N	.76973+04
NO	.33063+02	N2	.31816+00	NH	.64374+04
NH2	.126421+04	NH3	.88705+05	O	.30095+02
OH	.12701+01	O2	.45454+03		

STATION NO: 1

CP=FROZEN CP=EQUIL GAMMA
 J/KG-K J/KG-K
 .17077+04 .34581+04 .11929+01
 TEMP = 3843.7445 DEG-K PRES = 6.438+06 N/M2 MOL WT = 224.3700647
 ENTHALPY = .3354022+07 J/KG ENTROPY = .10875+05 J/KG-K
 DENSITY = .451926+01 KG/M3
 VEL = 4.423+02 M/S MACH NO. = 3.393+01

SPECIES	MOLE FR.	SPECIES	MOLE FR.	SPECIES	MOLE FR.
WALL GAS	1.0000	EDGE GAS	.00000	H2	.14014+00
CO	.39341+00	C(S)	.00000	C	.82149+07
C2	.18016+10	C3	.21281+13	C4	.36940+19
C5	.15529+22	CH3	.53311+07	CH4	.64737+08
C2H	.17393+08	C2H2	.24439+08	C2H4	.65371+12
CO2	.18235+01	HCN	.24685+04	H2O	.54343+01
H	.56095+01	HCO	.27872+03	N	.69063+04
NO	.31239+02	N2	.31875+00	NH	.58421+04
NH2	.24503+04	NH3	.84711+05	O	.27964+02
OH	.12217+01	O2	.42687+03		

OUTPUT DELETED

AXIAL DISTANCE, METERS	- .49278+00	- .45705+00	- .40649+00	- .30470+00	- .20291+00	- .15235+00	- .10179+00	- .50559+01
	.00000	.50559+01	.10179+00	.15235+00	.25414+00	.35593+00	.45705+00	.60940+00
	.76175+00	.91410+00	.10671+01	.12195+01	.14580+01	.15242+01	.16765+01	.19812+01
	.24383+01	.28953+01	.31333+01					
WALL LENGTH, METERS	.45518+02	.56188+01	.11287+00	.22321+00	.32911+00	.38054+00	.43164+00	.48303+00
	.53361+00	.58417+00	.63551+00	.68652+00	.79033+00	.89619+00	.10061+01	.11727+01
	.13391+01	.15051+01	.16710+01	.18350+01	.20910+01	.21622+01	.23260+01	.26518+01
	.31336+01	.36073+01	.38503+01					
RADIUS, METERS	.82916+00	.79343+00	.76782+00	.72535+00	.69636+00	.68692+00	.67951+00	.67546+00
	.67412+00	.67479+00	.67816+00	.68490+00	.70513+00	.73411+00	.77726+00	.84467+00
	.91140+00	.97747+00	.10415+01	.11022+01	.11951+01	.12215+01	.12815+01	.13968+01
	.15491+01	.16732+01	.17224+01					
XI, (KG/S) **2	.56677+03	.71849+02	.14756+01	.30035+01	.45134+01	.52545+01	.59965+01	.67484+01
	.74895+01	.82295+01	.89803+01	.97263+01	.11239+00	.12766+00	.14335+00	.16684+00
	.18983+00	.21241+00	.23468+00	.25633+00	.28960+00	.29877+00	.31970+00	.36083+00
	.42048+00	.47813+00	.50806+00					
PRESSURE RATIO	.93400+00	.90900+00	.88500+00	.82800+00	.76200+00	.73000+00	.68100+00	.63700+00
	.59800+00	.55880+00	.52500+00	.48300+00	.40200+00	.33100+00	.26500+00	.19900+00
	.15400+00	.12500+00	.10300+00	.87000+01	.69120+01	.65000+01	.57000+01	.45000+01
	.34000+01	.28000+01	.27000+01					
STATIC PRESSURE, N/M2	.64379+07	.62856+07	.61002+07	.57073+07	.52524+07	.50318+07	.46940+07	.43908+07
	.41219+07	.38517+07	.36188+07	.33293+07	.27709+07	.22815+07	.18266+07	.13717+07
	.10615+07	.86161+06	.70996+06	.59968+06	.47643+06	.44804+06	.39289+06	.31018+06
	.23436+06	.19300+06	.18611+06					
EDGE VELOCITY, M/S	.44230+03	.52227+03	.59035+03	.73182+03	.87529+03	.94022+03	.10359+04	.11194+04
	.11922+04	.12650+04	.13277+04	.14063+04	.15622+04	.17075+04	.18548+04	.20218+04
	.21540+04	.22519+04	.23359+04	.24045+04	.24915+04	.25136+04	.25594+04	.26368+04
	.27213+04	.27755+04	.27853+04					
BETAV	.36563+01	.28780+00	.44450+00	.77156+00	.95209+00	.12200+01	.13808+01	.12576+01
	.12325+01	.11827+01	.12753+01	.14633+01	.14214+01	.13966+01	.12473+01	.10769+01
	.91110+00	.77124+00	.70621+00	.62888+00	.57615+00	.54076+00	.50173+00	.51945+00
	.40221+00	.17545+00	.00000					
BETAP	.36563+01	.28780+00	.44450+00	.77156+00	.95209+00	.12200+01	.13808+01	.12576+01
	.12325+01	.11827+01	.12753+01	.14633+01	.14214+01	.13966+01	.12473+01	.10769+01
	.91110+00	.77124+00	.70621+00	.62888+00	.57615+00	.54076+00	.50173+00	.51945+00
	.40221+00	.17545+00	.00000					
INCID RAD.FLUX, W/M2	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000
	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000
	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000
	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000

STATION 1 - - - - - AXIAL POSITION - .49278+00 METERS - - - - -23 JUN 75 07:52:43

ITERATED VALUES

ITS	TIME	ALPHA	FPPW	DAMP	MAX. LIN ERROR	MOMENTUM	ENERGY	WALL G
1	21.738	4.178	.8005	.4999	7.000	14	8.600	11
2	28.256	4.816	.8560	.4831	4.000	14	7.000	11
3	32.203	5.298	.8717	.4268	2.000	14	5.500	11
4	35.933	5.827	.8863	.4949	1.000	14	4.400	11
5	39.367	6.410	.9058	.6588	5.001	14	3.200	11
6	42.649	6.974	.9361	.0000	2.001	14	1.900	11
7	45.680	7.107	.9568	.0000	2.06	14	4.401	11
8	48.703	7.116	.9587	.0000	1.06	14	3.102	6
9	51.816	7.117	.9587	.0000	5.007	9	1.904	6

ALPHA	RADIUS METERS	PRESSURE N/M2	EDGE VEL. M/S	BETAP	BETAV	HEAT FLUXES--W/M2
7.117+00	8.292+01	6.438+06	4.423+02	3.656+02	3.656+02	3.210+06

DIFFUSIONAL TOT ENTH RERAD 0.000
GCOND 9.671+06

WALL SHEAR MECHANICAL REMOVAL N/M2 2.049+03 0.000

MASS FLUXES KG/SM2
CHAR TOTAL GAS HYDROGEN CARBON

8.066+01 8.066+01 -3.452+03 -4.505+01

MOM TRANS HEAT TRANS COEFF. CF/2 2.317-03 4.609-03 0.000

BLOWING PARAMETERS
(NORM. BY RHOE*UE*ST) FOR
CHAR TOTAL GAS HYDROGEN CARBON

8.755+02 8.755+02 2.734+03 2.734+03

MOMENTUM DISPLACE. THICKNESS, THETA METERS 2.275+05 3.278+05 3.646+05 4.568+05 2.206+07 2.853+05 2.856+05

EFFECTIVE ENTHALPY REYNOLDS
BODY THICKNESS, NUMBER
DISPLACE. LAMBDA PER METER
METERS METERS METERS METERS

TOTAL HEAT TO WALL WATTS 0.000	THRUST LOSS (N) -1.118+03	TOTAL WALL AREA (M2) 0.000	ACCELERATION PARAMETER=K 1.821+07	INVISCID MASS IN BL KG/S 3.341+00	TOTAL MASS IN BL KG/S 3.380+00
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NODAL INFORMATION

ETA	DISTANCE FROM WALL METERS	F	U/UE	FPP	SHEAR N/M2	G, TOTAL ENTHALPY J/KG	GP J/KG	GPP J/KG	STATIC ENTHALPY J/KG	TEMP DEG-K
0.000	0.000	-1.808-01	0.000	9.587-01	2.049+03	3.103+06	4.944+04	-4.575+04	3.103+06	3.187+03
2.000+03	2.360-07	-1.807-01	1.367-02	9.625-01	2.053+03	3.104+06	4.879+04	-2.332+04	3.104+06	3.195+03
6.000+03	7.104-07	-1.800-01	4.118-02	9.700-01	2.061+03	3.105+06	4.758+04	-2.927+04	3.105+06	3.211+03
1.000-02	1.188-04	-1.784-01	6.888-02	9.761-01	2.069+03	3.107+06	4.675+04	8.433+04	3.106+06	3.228+03
2.500-02	3.011-06	-1.655-01	1.714-01	9.746-01	2.098+03	3.112+06	5.575+04	2.394+05	3.109+06	3.287+03
6.000-02	7.435-06	-9.770-02	3.566-01	5.429-01	2.134+03	3.134+06	1.154+05	-6.221+04	3.121+06	3.399+03
1.500-01	1.952-05	2.159-01	5.819-01	1.606-01	2.094+03	3.195+06	7.553+04	-2.267+04	3.162+06	3.550+03
4.000-01	5.468-05	1.451+00	7.760-01	5.762-02	1.761+03	3.293+06	3.520+04	-3.462+03	3.234+06	3.690+03
7.000-01	9.741-05	3.227+00	8.818-01	4.143-02	1.242+03	3.360+06	2.781+04	-5.027+03	3.284+06	3.763+03
1.000+00	1.405-04	5.189+00	9.500-01	2.250-02	6.673+02	3.408+06	1.707+04	-3.631+03	3.320+06	3.808+03
1.500+00	2.126-04	8.672+00	9.960-01	3.363-03	6.826+01	3.446+06	4.153+03	-1.666+03	3.349+06	3.839+03
2.500+00	3.572-04	1.579+01	1.000+00	0.000	0.000	3.452+06	0.000	4.990+02	3.354+06	3.844+03

DISTANCE FROM WALL METERS	DENSITY RHO KG/M3	VISCOSITY MU N-S/M2	SPECIFIC HEAT J/KG-K	THERMAL COND. W/M-K	PRANDTL NUMBER	MODIFIED SCHMIDT NUMBER	MOLECULAR WEIGHT	MACH NUMBER	RHOSQ*EPS /RHOE*HUE	TURBULENT PRANDTL NO
0.000	5.548+00	7.996-05	1.739+03	2.810-01	4.948-01	7.041-01	2.284+01	0.000	0.000	0.000
2.360-07	5.528+00	8.008-05	1.738+03	2.819-01	4.938-01	7.040-01	2.281+01	5.058-03	3.659+06	9.000-01
7.104-07	5.488+00	8.034-05	1.737+03	2.837-01	4.918-01	7.039-01	2.277+01	1.518-02	2.839+04	9.000-01
1.188-06	5.449+00	8.059-05	1.736+03	2.856-01	4.898-01	7.038-01	2.272+01	2.530-02	2.116-03	9.000-01
3.011-06	5.307+00	8.151-05	1.731+03	2.924-01	4.824-01	7.035-01	2.253+01	6.211-02	6.925-02	9.000-01
7.435-06	5.053+00	8.321-05	1.721+03	3.057-01	4.686-01	7.027-01	2.218+01	1.261-01	9.657-01	9.000-01
1.952-05	4.737+00	8.546-05	1.709+03	3.240-01	4.509-01	7.016-01	2.172+01	1.993-01	5.621+00	9.000-01
5.468-05	4.613+00	8.788-05	1.709+03	3.241-01	4.632-01	7.031-01	2.198+01	2.637-01	1.450+01	9.000-01
9.741-05	4.565+00	8.917-05	1.708+03	3.221-01	4.729-01	7.042-01	2.219+01	2.997-01	1.420+01	9.000-01
1.405-04	4.539+00	8.997-05	1.708+03	3.204-01	4.796-01	7.049-01	2.232+01	3.223-01	1.404+01	9.000-01
2.126-04	4.522+00	9.053-05	1.708+03	3.189-01	4.847-01	7.053-01	2.242+01	3.379-01	9.289+00	9.000-01
3.572-04	4.519+00	9.061-05	1.708+03	3.188-01	4.854-01	7.054-01	2.244+01	3.393-01	0.000	9.000-01

DISTANCE FROM WALL, METERS

0.000 2.360-07 7.104-07 1.188-06 3.011-06 7.435-06 1.952-05 5.468-05 9.741-05 1.405-04
2.126-04 3.572-04

LEMENTAL FRACTIONS AND THEIR FIRST AND SECOND DERIVATIVES WITH RESPECT TO FTA

WALL GAS 1.286-01 1.272-01 1.242-01 1.213-01 1.103-01 8.955-02 6.205-02 3.577-02 2.021-02 9.411-03
1.131-03 -3.599-09
-1.024-01 -1.028-01 -1.035-01 -1.041-01 -1.019-01 -6.458-02 -2.130-02 -8.240-03 -6.332-03 -3.787-03
-8.669-04 0.000
-2.616-02 -2.560-02 -2.162-02 2.129-02 1.497-01 6.756-02 7.343-03 8.937-04 1.192-03 8.206-04
3.532-04 -1.096-04
EDGE GAS 8.714-01 8.728-01 8.758-01 8.787-01 8.897-01 9.104-01 9.380-01 9.642-01 9.798-01 9.906-01
9.989-01 1.000-00
1.024-01 1.028-01 1.035-01 1.041-01 1.019-01 6.458-02 2.130-02 8.240-03 6.332-03 3.787-03
8.669-04 0.000
2.616-02 2.560-02 2.162-02 -2.129-02 -1.497-01 -6.756-02 -7.343-03 -8.937-04 -1.192-03 -8.206-04
-3.532-04 1.096-04

MOLE FRACTIONS

WALL GAS 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000
EDGE GAS 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000
H2 0.000 0.000 0.000
1.795-01 1.802-01 1.815-01 1.828-01 1.876-01 1.954-01 2.030-01 1.770-01 1.601-01 1.491-01
1.412-01 1.401-01
CO 4.671-01 4.671-01 4.671-01 4.671-01 4.671-01 4.669-01 4.654-01 4.380-01 4.189-01 4.054-01
3.949-01 3.934-01
C(S) 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000
C 0.000 0.000 0.000
4.568-06 4.747-06 5.113-06 5.491-06 6.926-06 9.106-06 2.959-06 1.217-07 9.588-08 8.732-08
8.263-08 8.215-08
C2 2.722-06 2.775-06 2.872-06 2.958-06 3.139-06 2.623-06 1.117-07 8.701-11 3.687-11 2.434-11
1.862-11 1.802-11
C3 2.517-05 2.478-05 2.389-05 2.289-05 1.833-05 7.999-06 3.490-08 4.164-13 8.542-14 3.837-14
2.274-14 2.128-14
C4 7.492-08 7.280-08 6.834-08 6.361-08 4.486-08 1.354-08 8.620-12 2.138-18 2.472-19 8.279-20
4.044-20 3.694-20
C5 1.620-07 1.530-07 1.354-07 1.186-07 6.577-08 1.119-08 8.046-13 3.331-21 1.946-22 4.552-23
1.753-23 1.553-23
CH3 1.810-04 1.789-04 1.745-04 1.699-04 1.508-04 1.048-04 1.506-05 2.392-07 1.123-07 7.385-08
5.536-08 5.331-08
CH4 1.021-04 9.896-05 9.295-05 8.716-05 6.757-05 3.676-05 3.875-06 4.339-08 1.688-08 9.865-09
6.800-09 6.474-09
C2H 2.972-03 2.932-03 2.846-03 2.751-03 2.324-03 1.288-03 3.268-05 1.503-08 4.834-09 2.692-09
1.827-09 1.739-09
C2H2 2.204-02 2.130-02 1.982-02 1.838-02 1.339-02 5.674-03 1.024-04 3.238-08 8.520-09 4.186-09
2.599-09 2.444-09
C2H4 2.455-05 2.339-05 2.119-05 1.912-05 1.263-05 4.475-06 6.375-08 1.389-11 2.945-12 1.258-12
7.050-13 6.537-13
CO2 1.175-05 1.194-05 1.234-05 1.278-05 1.484-05 2.236-05 1.610-04 7.223-03 1.204-02 1.538-02
1.790-02 1.823-02
HCN 5.847-02 5.764-02 5.595-02 5.421-02 4.730-02 3.212-02 4.574-03 8.533-05 4.485-05 3.191-05
2.542-05 2.469-05

H2O	3.400-05	3.474-05	3.630-05	3.800-05	4.580-05	7.344-05	5.653-04	2.396-02	3.813-02	4.713-02
H	5.351-02	5.434-02								
	1.435-02	1.469-02	1.541-02	1.614-02	1.909-02	2.572-02	3.710-02	4.660-02	5.130-02	5.404-02
HCO	5.585-02	5.610-02								
	2.017-04	2.039-04	2.084-04	2.130-04	2.301-04	2.635-04	3.094-04	3.076-04	2.973-04	2.880-04
N	2.733-06	2.865-06	3.147-06	3.454-06	4.822-06	8.791-06	1.873-05	3.571-05	4.910-05	5.945-05
NO	6.784-05	6.906-05								
	1.490-07	1.573-07	1.746-07	1.939-07	2.895-07	6.862-07	8.769-06	6.780-04	1.501-03	2.285-03
N2	3.014-03	3.124-03								
	2.549-01	2.555-01	2.567-01	2.579-01	2.626-01	2.723-01	2.886-01	3.023-01	3.096-01	3.146-01
NH	3.183-01	3.187-01								
	6.633-06	6.872-06	7.374-06	7.905-06	1.015-05	1.588-05	2.776-05	4.102-05	4.895-05	5.415-05
NH2	5.790-05	5.842-05								
	1.000-05	1.021-05	1.063-05	1.106-05	1.275-05	1.640-05	2.232-05	2.446-05	2.477-05	2.471-05
NH3	2.453-05	2.450-05								
	1.500-05	1.503-05	1.509-05	1.515-05	1.536-05	1.567-05	1.588-05	1.244-05	1.052-05	9.365-06
O	8.575-06	8.471-06								
	5.067-08	5.415-08	6.189-08	7.077-08	1.172-07	3.338-07	5.334-06	5.001-04	1.217-03	1.959-03
OH	2.684-03	2.796-03								
	1.051-06	1.102-06	1.212-06	1.334-06	1.927-06	4.288-06	4.999-05	3.287-03	6.604-03	9.430-03
O2	1.186-02	1.222-02								
	3.850-12	4.193-12	4.967-12	5.900-12	1.145-11	5.001-11	5.891-09	2.675-05	1.143-04	2.439-04
	4.005-04	4.269-04								

SURFACE SPECIES IS C(S)

REFIT CALLED

I	ETA(I)	U/U/E	G(I,I)	SP(1,I,1)	SP(1,I,2)	SP(1,I,3)	SP(1,I,4)	SP(1,I,5)	SP(1,I,6)	SP(1,I,7)	SP(1,I,8)
1	0.000	0.000	3.103+06	1.286+01							
2	7.277-03	4.981-02	3.106+06	1.233-01							
3	1.742-02	1.204-01	3.109+06	1.158-01							
4	3.767-02	2.495-01	3.118+06	1.018-01							
5	5.831-02	3.504-01	3.132+06	9.029-02							
6	8.702-02	4.494-01	3.155+06	7.845-02							
7	1.662-01	6.037-01	3.204+06	5.923-02							
8	3.467-01	7.469-01	3.277+06	3.981-02							
9	5.989-01	8.516-01	3.340+06	2.478-02							
10	1.000+00	9.500-01	3.408+06	9.411-03							
11	1.234+00	9.792-01	3.431+06	4.306-03							
12	2.500+00	1.000+00	3.452+06	-2.794-09							

REMAINING OUTPUT DELETED

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